S. A. E. JOURNAL

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The purpose of meetings of the Society is largely to provide a forum for the presentation of straightforward and frank discussion. Discussion of this kind is encouraged. However, owing to the nature of the Society as an organization, it cannot be responsible for statements or opinions advanced in papers or in discussions at its meetings. The Constitution of the Society has long contained a provision to this effect.

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London Motor-Transport Sessions

Representatives of 50 Nations Discuss Matters of Worldwide Interest—Rail and Road Coordination Emphasized

The World Motor-Transport Congress for 1927, which was held in London in November, was a distinct success. The hearty thanks and congratulations of all interested in broad motor-transport problems are due to the Society of Motor Manufacturers and Traders, Ltd., of Great Britain, to Horace Wyatt, organizer, and to various cooperating organizations and individuals. Contemporaneously with the Conference, the magnificent Commercial Motor-Transport Exhibition was held at Olympia, marked developments in commercial motor-vehicle design being shown. During the month, sessions were held by the Institution of Automobile Engineers, the Institute of Transport, the Commercial Motor Users' Association, Inc., and the Incorporated Association of Retail Distributors, as well as luncheon-meetings of the Society of Motor Manufacturers and Traders every day during the show.

The representatives of the Society of Automotive Engineers who participated in or contributed to the sessions were David L. Bacon, N. D. Ballantine, H. L. Horning, and Coker F. Clarkson. Other S. A. E. members who were on the ground at the time for the purpose of furthering international cooperative effort and exchange of information included Karl D. Chambers, J. B. Fisher, R. C. Hoffman, Fred Neale, Mason P. Rumney, and D. O. Scott. The Department of Commerce of the United States was represented by H. H. Kelly, automotive trade commissioner for Europe, and William M. Park, trade commissioner to the United Kingdom. Cortlandt Bishop, European representative, and J. D. Ryan, director of the foreign department, attended on behalf of the American Automobile Association. H. L. Horning also represented the Motor and Accessory Manufacturers Association as its president. The delegates of the American Chamber of Commerce were G. M. Cassett, Walter Mangum and H. R. Amory. G. F. Bauer, manager of the foreign trade department of the National Automobile Chamber of Commerce, took a prominent part in the proceedings of the Congress, he having been closely identified with similar congresses held in this Country. The Congress was attended by about 250 delegates representing 50 countries. In many cases Governments sent delegates.

Rail and Road Coordination the Problem

Sir George Beharrell, president of the Society of Motor Manufacturers and Traders, presided at the first session. The delegates were welcomed on behalf of the British Government by Lieut-Col. Wilfrid Ashley, minister of transport. He said that the problem to which every thinking man must turn his attention is how the great railway systems of the world can be fairly coordinated with road transportation. He expressed the opinion that consideration and sound business capacity should enable the leaders of the two interests to devise a plan that will be mutually advantageous, eliminating wasteful competition. W. Ormsby-Gore, under-secretary for the colonies, called attention to the fact that the cost of transportation to market renders many products unmarketable, and that knowledge of roads as affected by motor traffic under varying conditions in present advanced development of motor-vehicle operation is incomplete.

Transportation Needs of Australia

It was stated on behalf of the Development and Migration Commission in Australia that the demand for more and better transport there is constant and that if the development of the country is to proceed unchecked it is imperative that adequate transport facilities be maintained. The great disability of the Australian railway system as a whole is the difference of gage in the various State systems. It will be many years before the proposal to establish a standard-gage main-line some thousands of miles in length can be carried out. While Australia has a greater length of line per capita than any other country except Canada, she has only 9 miles of track per 1000 sq. miles of area, the lowest in any country. Great Britain and the United States of America have respectively 223 and 86 miles per 1000 sq. miles.

Not more than one-fifth of the Australian highways are metalled or suitable for heavy traffic. The unmetalled roads are fairly adequate for light motor-traffic. At times, however, these highways are almost impassable. In the country the motor-car has become a necessity to the man on the farm. The cost of heavy transport by horse team in the back country ranges from 20 to 30 cents per ton-mile. The cost of gasoline varies from $0.48 to $1.25 per gal., according to the distance it has to be transported. These prices and the road conditions constitute the principal reasons the motor-truck cannot compete with the horse team in heavy transport. The competition of the motor-car and the motorcoach as passenger carriers is being felt by the railways. The amount of freight carried by road in competition with the railways is small. It is felt that the six-wheel vehicles present opportunities for extending transport facilities in the country districts. In conclusion, the Commission says that it is doubtful if any other country has a greater prospect of development and expansion than has Australia.

Road and Traffic Conditions in Europe

Major R. A. B. Smith, of the Commercial Motor Users' Association, presented a paper on Road Construction and Improvement in Relation to the Development, Efficiency and Economy of Road Transport. He discussed bypass roads, improvement of roads in general, annual road costs, and modern American road-planning, concluding that the time is rapidly approaching when the onus of providing

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Meetings Calendar

Annual Dinner

Jan. 12, 1928
Hotel Astor, New York City

Annual Meeting

Jan. 24 to 27, 1928
Book-Cadillac, Detroit

Summer Meeting

June 26 to 29, 1928
Chateau Frontenac, Quebec

Sections Calendar

Buffalo Section Meeting—Jan. 3, 1928
Automotive Fuel Research—G. G. Brown

Metropolitan Section Meeting—Jan. 9, 1928
What's New at the Show—Descriptions of the new Auburn, Buick, Cadillac, Chrysler, Dodge, Franklin, Locomobile, Marmon, Moon, Paige-Detroit, Peerless, Pierce-Arrow, F. B. Stearns, Stutz, and Velie models by the chief engineers of the different companies

New England Section Meeting—Jan. 11, 1928
Scientific Valve Reconditioning—Jack Frost

Southern California Section Meeting—Jan. 13, 1928
Magneto and Battery Distributor Ignition-Systems and Servicing of the Entire Electrical System—Robert Parker, E. E. Tattersfield and other speakers

non-slippery roads will be placed legally on the authorities concerned. Chief Engineer C. H. Bressey, of the Roads Department of the Ministry of Transport, and Chairman W. Rees Jeffreys, of the Road Improvement Association, participated in the discussion.

Senatore Crespi, president of the Royal Automobile Club of Italy, told in a very interesting manner of the newly constructed motor roads (autostrada) of Italy, these roads being similar in a general way to the Long Island Motor Parkway. He said that if the revenue derived from taxation of motor-vehicles is applied to the construction of these roads, the financial problem becomes an easy one. In Germany, motor traffic is not developed greatly. In the opinion of Herr Pflug, of the German Ministry of Transport, the most important thing is to adapt existing roads to the requirements of modern traffic most economically. M. S. Okecki, of the Ministry of Public Works of Poland, said that the greatest need there is light strong motor-vehicles, as only soft material is available for the construction of roads. He reported that in Poland there is only one automobile per 2000 inhabitants, but that there is a general keenness there to purchase automobiles.

T. Otaki, of the Motor Transport Association of Japan, suggested the possibility of organizing an international road-building company for the purpose of building roads in Manchuria and Siberia. He believes there is a great future for motor-car travel over long distances.

Six-Wheel Vehicles Much Discussed

The six-wheel vehicle was much discussed at the Congress and was exhibited in astonishing numbers at the Olympia Exhibition. Following the issuance in 1923 by the British War Department of subsidy specifications for a 1½-ton truck, and the crossing of the Sahara Desert by the Renault six-wheeler, in 1925 a design for the rear bogie of a six-wheel vehicle was undertaken by the War Office Experimental Staff at Aldershot, and it was decided to approach the British manufacturers with a view to their producing the vehicle. At the present time light six-wheel trucks are produced by three British makers, and seven additional firms are engaged in the production of medium-size six-wheel trucks. The six-wheel vehicle includes the technical features of the lighter subsidy-vehicle and has double the carrying capacity, both on and off the road, of the latter. A 5 to 6-ton vehicle is also under way.

Any vehicle constructed to a specification issued by the British War Office by an approved firm holding the subsidy certificate and operated in Great Britain or Northern Ireland is eligible for a grant from the War Office of $100 annually for 3 years, subject to a satisfactory semi-annual inspection as to maintenance and condition. In a National emergency these vehicles may be taken over by the military authorities on the basis of an agreed rate of depreciation. The number of vehicles so enrolled is 1000. The policy is to give preference to six-wheel vehicles of the type known as the War Office medium rigid-frame six-wheel truck, the specification for which has been issued recently. The vehicle can carry a 3-ton load, or in some cases a larger one, on good roads. The British Army will adopt a 2-ton load on bad roads or in heavy going. It is stated that in army maneuvers in Egypt near Cairo the presence of the six-wheel light trucks practically saved the transport service from a breakdown. In China the vehicles have been tried out under most difficult conditions, the wet paddy-field, and the performance far exceeded expectation.

Development of the track machine by the British War Office has been confined mainly to vehicles for special purposes, such as purely fighting and agriculture. It is said in the statement of the Office that the lines of development of the wheel and the track vehicles may lie along converging forces, and that in the cross-country vehicle of the future the advantageous features of both types will be combined.

English Method of Taking the Torque

Sir John E. Thornycroft, in a paper he presented, said:

> The method generally adopted for taking the torque in the American and the French six-wheel vehicles has been to couple the two axles together by some member along the center-line of the vehicle, which would prevent them from rotating about their own transverse axis on the vehicle but leave them free to do so about a longitudinal axis, the axles being supported by a spring or springs pivoted at the center and attached to the axles at the end. The method adopted by the British War Office is to hold the axles in their relative positions by the ends of the supporting springs, which have one central pivot and take the torque due to the drive by means of links connected to some point on the axle casing above the center-line, so that the links and the springs act as a couple to prevent its rotation. These links must be fitted with some form of joint having three degrees of freedom, and therefore a ball-joint is adopted. While this arrangement has worked well, in my opinion a better arrangement is to employ two independently pivoted springs themselves to take the torque. If this is adopted, not only are the pressures on the pins due to the torque very considerably reduced, but what is equivalent to a spring drive results, a most important feature where the full effort of the engine is brought to work through very high gear-ratio.

Sir John expressed the opinion that the spring-mounting for vehicles to travel over really bad roads must provide for a transverse difference in level of the wheels of about 2 ft.; also, that with 5¾ tons as the normal gross load of the War Office subsidized six-wheeler, the tractive effort required to overcome the resistance of sandy surfaces, such as that at Aldershot, would amount to 2600 lb.; however, the tractive effort available in the Thornycroft A-3 type fitted with a rear-axle ratio of 8¾ to 1 amounts to 7000 lb.

In connection with the motorcoach service between Damascus and Bagdad, Norman Nairn expressed approval of the six-wheel vehicle and interest in the production of an eight-wheel vehicle. Sir William Hoy, general manager of the South African Government Railways and Harbors, said in his paper that in South Africa last summer six-wheel vehicles were able to maintain a scheduled service when the muddy condition of the roads made it practically impossible for ordinary passenger-cars to move. An auxiliary gear, which, with the ordinary gear, gives eight forward and two reverse speeds, has been found essential in difficult country. If experience demonstrates the practicability of hauling heavy traffic by mechanical transport at economical cost, the experiment will have far-reaching influence on the development of the various classes of farming operation of South Africa.

International Touring and Traffic Congestion

M. Adrien Lachenal, representing the Touring Club de Suisse, presided at the session devoted to improvement of facilities for international travel by road. The Earl of Birkenhead, secretary of state for India, discussed the need for standard signposting and in due course for uniformity in the rule of the road. Referring to this matter of turning to the right or to the left, Stenson Cooke, secretary of the Automobile Association, felt that the question should be left as it is for the time being. He gave an historical sketch of the development of international touring regulations. At the present time it is the rule of the road in 27 countries to turn to the right; and to turn to the left in 14 countries. Mr. Cooke felt that if a change is to be made in the rule, the "left-hand" countries will have to give up their present practice.

Referring to the need for an international motoring dictionary, Mr. Cooke mentioned the polyglot dictionary and

phrase book of the Touring Club of Belgium, saying that this deserves to be more widely known.

Mervyn O'Gorman, of the Royal Automobile Club of Great Britain, submitted a very interesting paper on road traffic congestion and related problems. He expressed the opinion that the best way to study traffic conditions is from the air, saying that, after having observed London traffic for 25 years, he was surprised when flying above the streets, which when on the ground he thought glutted with vehicles, to find that the street area darkened by them was many times less than the empty area. Streets were blocked mainly by vehicles whose drivers had no particular preference for the knotted localities but got there only because the finding of an alternative route was difficult.

R. Filser, on behalf of the Allgemeine Deutscher Automobil Klub, pointed out that the freedom granted to automobiles used for international touring purposes is founded on the fact that no country requires a special permit for the temporary importation of an automobile, and on the "régime des triptyques," which enables every tourist to effect security for customs duties in a very simple manner. This freedom is, however, restricted in many European countries if a particular vehicle is not used solely for touring. Only a few countries grant the facilities accorded to touring automobiles to motor-trucks and other vehicles used for business purposes; namely, Belgium, Denmark, Germany, Switzerland and the Netherlands. It has been stated that the railways will have to encounter more competition if international motor-truck traffic is extended; also that effective control over the use of foreign motor-trucks cannot be had. However, Belgium, which a short time ago opposed facilitated frontier crossing for motor-trucks, has after careful consideration released Bedgian triptyques for motor-trucks as well as for passenger-cars.

A resolution was passed that it was the sense of the Congress that the development of international touring should be encouraged by the various governments by all means possible in the interest of international amity. Also the importance of facilitating the crossing of frontiers by motor-trucks was emphasized.

Cooperation Between Rail and Road

Major-Gen. S. S. Long, chairman of the traffic committee of the Federation of British Industries, presided at the session devoted to The Necessity for Cooperation between Road and Rail Transport. David L. Bacon, a delegate of the Society of Automotive Engineers, presented a paper entitled Benefits of a Coordinated Rail and Highway System in New England. He also read a contribution on the topic of the session by N. D. Ballantine, another member of the Society, who was unable to be present at the session. Mr. Bacon cited the fact that about 5 years ago the tremendous improvement in highways in this Country, the all but universal ownership of automobiles and the rapid development of the use of the motorcoach as a means of interurban transportation combined to interfere seriously with the equilibrium of passenger traffic as a whole. The loss to the New York, New Haven & Hartford Railroad, of whose automotive equipment Mr. Bacon is supervisor, amounted in expected passenger revenue to $27,000,000 annually, and $3,300,000, or 12 per cent, was collected by independent motorcoach lines. The total number of passengers carried by the railroad declined about 40 per cent, this decrease being entirely in short-haul business. The railroad was forced, therefore, to curtail its service. However, Mr. Bacon stated there is business enough for both forms of transportation. He quoted Professor Cunningham, of Harvard University, as having said at the Transportation Meeting of the Society held in Boston in 1926 that the railroads will continue to take care of the long-journey passenger, the overnight traffic between large cities, and the mass movement of suburban passengers morning and evening. It is not a question of survival of one and the downfall of the other.

The New Haven Railroad now has 36 gasoline rail-cars in use, ranging from the original type of 60 hp. and seating 35 passengers to a more recent model in which a 250-hp. gasoline engine, delivering power electrically to the wheels, propels a 74-ft. car carrying 90 passengers at speeds up to 55 m.p.h. It has thus become possible for the road to continue to give rail service on many branch-lines, usually not at a profit but at a cost not entirely disproportionate to the direct revenue.

The railroad now has 191 motorcoaches that cover 1245 miles of highway, running up to a total of nearly 7,000,000 miles and carrying 4,500,000 passengers annually, which, it was pointed out in the discussion, is a small amount of motorcoach traffic compared with that in England. The motorcoaches are operated over 40 routes, averaging 30 miles in length. With few exceptions, the fare is the same on motorcoach lines and on steam trains. With reference to the Boston-New York City run, some travelers prefer to make this trip by motorcoach, a choice involving about twice as much time, but saving $1.50 if the trip is made by day, or $3.00 by night. Travelers on this route seem to be of two classes: those to whom the reduced fare is the chief attraction and those who enjoy the more leisurely and intimate views of the New England countryside. In one city motorcoaches are loaded to capacity from the sidewalk in the midst of the shopping district, while 200 yd. away across a public square trains charging a lower rate wait almost in vain for passengers.

Mr. Bacon said that of two vehicles scheduled to leave simultaneously on the same run, a long low one having an appearance of speed and power will be filled with passengers, while a higher one takes only the overflow. Luxury, or the illusion of luxury, is a factor not to be underestimated. For soft deep cushions, scientifically designed, plenty of leg-room and seat-backs set at a comfortable angle, public road-service organizers are more indebted to motorcoach builders than to railroad equipment manufacturers; and, although motorcoach passengers are probably less accustomed to luxury in their own homes than are those who ride on express trains, they have been educated by motorcoach makers to demand a standard of comfort, ventilation and accessories superior to that generally available in rail equipment. Mr. Bacon's conclusion was that the operation of highway motorcoaches, properly coordinated with the railway to give a complete transportation service, is advantageous to both the traveling public and to the parent railroad company, and consequently to the community at large.

The Economics of Transportation

Mr. Ballantine made a plea for cooperation and coordination of rail, highway and, eventually, airway transportation. He said that the duty of transportation men is to provide transportation service for persons and things in the safest, most expeditious, comfortable and economical manner by coordination of the different means. Within the last 2 years 51 railroads in the United States have begun the use of motorcoaches and trucks. Information as to the results of their operations is meager. Sufficient and uniform data must be kept before we can judge finally what is economically sound or make proper comparison. In the last 6 years the proportion of sleeping-car and parlor-car passengers to the total number carried by Class-1 railroads in the United States has increased more than 26 per cent. The same trend is seen in the additional passengers attracted by the motorcoaches. The higher fare-rate has been cheerfully paid by the public, showing that improved service and equipment would bring some of the business back to the rails. Gas-electric and Diesel-electric rail-cars are now used extensively and effect a saving of from 20 to 50 cents per train-mile as compared with steam-train operation. The rail-cars are clean, comfortable and speedy.

On our West Coast, where climatic and highway conditions are most favorable to motorcoach operation, a through route has been established covering 1380 miles. As a rule, however, the average long-distance motorcoach ride

does not exceed 50 miles. The railroads should augment their train service in certain localities to include motorcoach delivery of passengers to the principal hotels.

Need Data on Freight-Handling Costs

With regard to freight, Mr. Ballantine said the general tendency in the United States is to ship in smaller consignments as the service improves. The average less-than-carload loading for closed or box-cars is 7 tons, while the average weight of the car is 21 tons. Approximately every second time the car is loaded it is with less-than-carload freight. In 1920, Class-1 railroads handled 16,000,000,000 ton-miles of less-than-carload traffic; in 1926 they handled 12,000,000,000 ton-miles, a decrease of 25 per cent. The railroads could, with only a nominal increase of expense, handle the traffic now being taken away from them by truck. It is costing them nearly as much to handle the 75 per cent as it did the 100 per cent, and the loss of the 25 per cent takes away any profit there might have been on the original 100 per cent.

Under present conditions, the trucker chooses the traffic most remunerative to him, while the railroads must carry what is offered to them. There is no hard-and-fast rule by which to determine what should or should not go by truck or rail. There is an economic limit of highway transportation which can be discovered only by actual operation of coordinated transportation facilities. The distance which sand, gravel, brick and the like can he handled by trucks in competition with rail is relatively short, say 10 to 15 miles; but household goods, furniture and other commodities which must be carefully crated or packed to be accepted by rail carriers, the truck can handle economically up to 200 miles, and the speed with which delivery can be effected cannot be approached by the railroads, with the switching and terminal delays involved. One road reports that 50 per cent of the freight received at its largest terminal is given store-door delivery. This practice will become more general when the railroads realize fully what it means to them in releasing cars for other business, in relieving terminal congestion and the resultant savings in terminal costs.

Class-1 railroads in the United States do not yet know much about the real cost of handling traffic in their terminals; but they do know that terminal congestion is causing delays that are unwarranted and uneconomical on short-haul less-than-carload business.

Street-Car and Motorcoach Coordination

It is in our cities of 150,000 population or less that the electric railways have experienced the most difficulty. In the extreme cases the entire system of tracks has been removed and motorcoach service substituted, while in other cases a coordination of street-railway and motorcoach has enabled the companies to continue operation. The Grand Rapids Railway Co., of Grand Rapids, Mich., was awarded recently the Charles A. Coffin medal for accomplishments in the rehabilitation of its lines in the last 2 years. It has replaced all of its old equipment with modern steel cars, and by increasing the operating efficiency and reducing costs, it has maintained the same rate of fare and shown a higher percentage of revenue. This shows what a desire to improve service, coupled with 100-per cent cooperation in an organization, can do. The Detroit Street Railway is using motorcoaches for local and street-cars for express passenger service. The motorcoaches start at a point beyond the rail lines, in the less populated sections, then run parallel to the rails and make the local stops, delivering passengers to express-car platforms placed every few blocks. Motorcoach and street-car both operate as local in the business section. The public is showing its appreciation of the new service by increased patronage.

Our electric railways generally, during recent years, have either obtained or are seeking increased rates to earn sufficient revenue to pay interest on their funded debts. In addition, a large number of independent motorcoach and truck operators are not showing a profit. There are few trustworthy data upon which to compare the merits of the various makes of automotive equipment, because of the rapid strides and overnight changes in construction, combined with insufficient knowledge as to manufacture, which must be had to evaluate and compare properly. All transportation agencies, Mr. Ballantine argues, will find their interests best served by cooperation and complete coordination of rail and motor transport.

Conditions in Europe

T. S. Haltenberger, engineer of the Motor Transport Co. of the Hungarian Railways, said that in Hungary, which is mainly an agricultural country, the automobile movement has given rise to competition with the railways as regards both passenger and commercial goods transportation. On the lines having a length of less than 60 miles there has been a falling off in the goods traffic of 20 per cent, while in passenger traffic, particularly between stations necessitating change of train, the decline has been from 50 to 70 per cent. Accordingly, the Motor Transport Co. was organized by the railways in 1926, the system adopted being based in part on British and American practice.

In a statement submitted by the delegates of the German State Railway Co. and of the Office for German Railway Motor Traffic, it was shown that in Germany, as in other countries, the motor-vehicle has diverted a considerable part of the passenger and the freight traffic from the railway. This loss is felt chiefly in hauls up to 70 miles. The German Reichs Railway Co. has concluded that cooperation between railway and motor transport is in the interest of both means of transport and of the public. The Company, therefore, in 1924, made with all the large motor companies of Germany, united under one mother company, an agreement that, if certain traffic is to be diverted from the railway to the motor-vehicle, a special operation contract is to be signed according to which the mutual rights and obligations, the tariff and the distribution of possible surplus profits are fixed. On Sept. 1, 1927, 61 railway and road transport lines were in operation. Of these, 22 are engaged solely in passenger traffic, 37 in freight traffic, and 2 in mixed traffic.

However, there is no unity and regularity in the whole traffic service. Traffic is in part diverted uneconomically and to no purpose from the railway. This causes the railway to take steps to counteract this in the way of organization and tariff, rendering necessary further unprofitable methods. To this extent the public is harmed, the railway suffers loss, and the motor-vehicle does not achieve its object. By reasonable adaptation of the motor-vehicle, it can supplement transport by rail and improve and extend its service. Unhealthy competition, the German delegates declared, can thus be excluded and the public transport service properly developed.

M. A. M. Pourcel, chief engineer of the Paris, Lyons & Mediterranean Railway, told of the extensive motorcoach services that had been developed by that organization. The railway company controls closely the running of the services, prepares the time-tables, fixes the fares, and decides on the type of vehicle to be used. The most generally used type is the Pullman 14-seated coach, having five rows of three arm-chairs. The express services are maintained by 11-seated vehicles. The French organization makes possible the visiting of the extremely varied districts of France. There exist in France different groups of public transport services: free services, services run in accordance with the regulations, or with subsidies from department and communal authorities, with or without State aid. Over and above the main railway system, the secondary lines and the local railways, the motor-vehicle forms a sort of capillary system which can penetrate every corner of the country, developing traffic and the exchange of commodities.

Major James Paterson, jointly with J. B. Osler, submitted a paper on behalf of the Commercial Motor Users' Association. It will be recalled that in 1924 Major Pater-

son presented a paper at a meeting of the Society entitled Small-Consignment Commodity Distribution in London and Environs.

Major Paterson stated frankly and forcefully that the way for rail and road to cooperate is *to cooperate*. In this a representative of the War Office concurred, saying that transportation should be economical, independently of the medium which conducts it. Major Paterson pointed out that, when the railway replaced the coach and horses, the whole of the capital of the coach companies was lost; today, when the motor-car is available either to replace rail movement or to cope with a certain proportion of the increase in general movement of persons and goods which has arisen, it may well be that some part of our investment in railways is obsolete and should be scrapped. Few, however, would be found to say that any substantial part of the investment in British railways is obsolete. Road carriers who owned horses, horse stables and horse-vehicles have, of course, had far more difficult problems; all or almost all of their plant and properties have become obsolete and have had to be ruthlessly scrapped; and they have had to re-equip with new motive plant, at first of primitive and inefficient type, involving much more capital than did the old equipment. They also had to learn engineering, their knowledge of horse-mastership being of no further use, and they have had to evolve a new basis of knowledge in respect to cost of moving tons and hundredweights per mile, and the like.

Major Paterson averred that it therefore seems that those engaged in working railways should desire cooperation with modern road-transport, cooperation meaning partnership on an equal basis and for the public good, so that, wherever the railway can offer either passengers or goods a service equal or superior to any other, there should be available services by modern road-transport of access to and delivery from the points where the rail transport respectively begins and ends. Then the public would have available a complete movement. Incidentally, conveyance of goods in bulk in containers suitable for mounting on both road and rail vehicles, as now being developed slowly in the United Kingdom and in the United States, should be carried further.

Resolution Passed Favoring Cooperation

Col. Alfred Hacking, secretary of the Society of Motor Manufacturers and Traders, proposed the following resolution:

> In the opinion of this Congress, cooperation between railway and motor transport is in the interests of both means of transport and of the public.

Coker F. Clarkson, General Manager of the Society of Automotive Engineers, in seconding this resolution, which was carried unanimously, said:

> On behalf of the Society of Automotive Engineers of the United States of America, I wish to make it clear that we are much gratified and very thankful to be represented at this gathering of superb purpose. It is an indication of the better intelligence and feeling of worldwide organizations that can do something about many pressing problems of essentials of transportation. We are arrived at a place where the whole transportation service of the world must be restudied, and fundamentals outlined and defined.
>
> Old methods, never thoroughgoing, are inadequate and are passing. A central nervous system that will, so far as possible, and increasingly, function effectively must be evolved. This system must react in a rational way, so far as may be, throughout the ramifications of our whole immense field of transport operations. The older forms of transportation, notably the railroads, have much to learn of economic operation. The traditions of the older schools must relax and give way. The antique methods of horse-drawn vehicle operation are about gone. Well-trained personnel in the automotive engineering operating and maintenance field is being developed.
>
> Much has been done in the engineering design, production, standardization, and research of automotive vehicles. Much more can and must be done. The relation to these of operation and maintenance engineering is only beginning to be understood. Service to the public is the only thing to consider and look toward. There must be standard nomenclature so that those concerned will talk the same language. There must be standard cost-keeping so that results of different operators can be compared. There must be general dissemination of knowledge of conditions so that what can be and should be done can be understood. Intelligent statutory provisions and regulations must be outlined and enacted.
>
> Obviously, the various forms of transportation are intimately connected: the watercraft; the railways, operated by steam, electricity, and internal combustion; the motor-truck; the tractor; the motorcoach; and the aircraft. The Society of Automotive Engineers has long been devoted to the solution of the problems involved. Its 6000 members are scattered throughout 30 nations of the world. We promise our best efforts in any assistance we can render. We shall be glad to interchange information with fellow-workers wherever located. Our organization is essentially a cooperative one. Billions of dollars of savings can be made annually in due course by proper procedure; and untold increased comfort and happiness rendered to man. Hundreds of millions of dollars have for years been saved annually by the automotive engineering standardization and research work conducted cooperatively in the United States of America. This is only a beginning of what can be done in a worldwide way; and must, it seems to us, be done, if intelligence and reason are to reign.

An additional resolution was passed to the effect that the delegates of industry, commerce, and motor organizations at the Congress view with grave misgiving the growing tendency of some governments to obtain revenue by excessive taxation of motor-transport vehicles, thereby impeding the natural development of commercial motor-transport and favoring State enterprise; and that all organizations and individuals concerned should be appealed to to oppose this tendency and to facilitate by any means within their power the development of the important motor-transport industry.

Next Meeting at Rome

Senatore Crespi announced a message he had received from H. E. Benito Mussolini inviting the Congress to hold its next meeting in Rome. This was received enthusiastically and the invitation was accepted. It is understood that the next Congress will be held at Rome in September of this year.

Military-Transport Vehicles

At the joint meeting of the Institution of Automobile Engineers and the Institute of Transport, Capt. C. H. Kuhne, of the British War Office, presented a paper on recent developments in motor-transport vehicles and their commercial significance. His paper is well worth study, as it states comprehensively the British program as to six-wheel vehicles, three-wheel motorcycles and subjects related to such equipment.

The British War Office has been guided by the principle that in general its transport vehicles must be of types which can be recommended for commercial use. The ideal visualized is the evolution of one type of vehicle which will be the best of its kind for both cross-country travel and for use on good roads. The 30-cwt. subsidy-type light truck was fostered into commercial existence by a substantial cash subsidy. It is a fast, robust vehicle mounted on

pneumatic tires and represents the post-war step by the War Office to replace the old 3 to 4-ton solid-tire truck of the war with a vehicle having an increased power of movement. This truck, Captain Kuhne states, was a success both militarily and commercially, its existence enabling definite new steps in the mechanization of the army to be undertaken. It is likely to occupy an important place for some time in the army's transport scheme for war. Having small load-capacity, it requires too much road space for war conditions and is uneconomical with respect to manpower; and its cross-country ability, though representing a step forward in 1923, is not adequate.

Requirements of Subsidized Six-Wheel Trucks

It was felt that more driving-wheels per vehicle must be provided. The brake horsepower of the engine of the medium-size six-wheel truck must, between 600 and 1400 r.p.m., be not less than the figure obtained by dividing the revolutions by 40. Accessibility is assured by laying down time-limits for decarbonization and for examination of big-end and main bearings. Dry-sump force-feed lubrication is desired. Plain bearings of ample size are preferred to ball bearings on universal-joints. On existing vehicles the pressures on universal-joint bearings and the propeller-shaft splines reach 1800 and 4000 lb. per sq. in. respectively. The engine and gearbox units are to be mounted on three-point suspension unless the suspension of the main frame itself on the axles is such as to make this unnecessary. The rear suspension must be such that within specified limits the relative movement of the driving wheels to follow the contour of the ground is permitted without spring flexure. It is also essential that the equalness of weight distribution over the driving-wheels shall not be disturbed unduly by any conditions of tractive or braking effort. It is not desired to lengthen the effective wheelbase to such an extent that the tendency of the vehicle to "belly" on rough ground will be increased. For this reason, the War Office is prepared to accept, in subsidized vehicles, forward control-position for the driver.

One of the brakes operates on the drums on the hubs of the first driving-axle and the other on drums on the hubs of the second driving-axle. Since there is no differential-gear between these two axles, each brake is in effect a four-wheel brake, and the shoes can be made of ample width. Front-wheel brakes seem to be superfluous on the six-wheel vehicle.

Standards of the British Engineering Standards Association and the Society of Motor Manufacturers and Traders are specified wherever possible.

It is suggested that the six-wheel vehicle complies with the primary desiderata of rapidity, smooth-running, economy and safety far more nearly than any conventional four-wheel vehicle. Therefore the hope is expressed by Captain Kuhne that, aided by the subsidy, vehicles to meet the requirements of the War Office will take their place in the hands of commercial users in increasing numbers. The subsidizing of civil-owned vehicles for military use in emergency is under consideration in India and in Australia. It is stated that qualified opinion is to the effect that, for unit loads up to about 5 tons at least, the need for track equipment is definitely confined to a very limited number of exceptional conditions. The War Office type over-all chain has been developed to enable the six-wheel vehicle to cope with the more extreme conditions of soft and slippery ground. Vehicles can run at from 15 to 20 m.p.h. with the chains fitted. It is said that the chains make surprisingly little noise.

Three-Wheel Army Motorcycle

The British army needs a single-track vehicle which will carry a person over country which a six-wheel truck cannot negotiate. It appeared that more driving and contact area with the ground, good belly clearance, a very low bottom-gear, light weight, and a low center-of-gravity were required. It was desired to establish whether a motorcycle with three wheels in line would be stable and ridable. If so, the two small driving-wheels with large-section tires would give increased supporting and driving area, while the bogie mounting, on similar lines to those of the six-wheel truck, would assure the wheels following the ground closely and secure the maximum adhesion. Preliminary tests have shown that a vehicle so constructed will travel over loose, soft and boggy ground hitherto denied to the ordinary motorcycle, that it is easier to ride and to control on rough ground, and handles well on the road. The easily detachable band running over the two driving-wheels works well and assists the machine considerably on soft ground.

In the discussion of Captain Kuhne's paper, Major-General Long said that the six-wheel vehicle is more costly to purchase, but not to run. He felt that the easiest way to encourage the commercial use of the vehicle is to reduce the tax on it, rather than by payment of subsidy. E. S. Shrapnell-Smith, president of the Commercial Motor Users' Association, stated that the advantages counterbalancing the greater first-cost of the six-wheel vehicle must be demonstrated to the commercial user. G. W. Watson reported that a test made by him showed that a third differential-gear, between the driving-axles, is not needed. H. G. Burford called attention to the fact that in military service certainty must outweigh considerations of economy. He argued that the government should establish standards, as the subsidy plan would not be workable. He also warned against vehicles of too great weight and size. He feared that in case of war motor-transport conditions would be worse than they were in 1914. He advocated that the government should maintain a group of vehicles as a nucleus ready for military requirements in emergency.

S. S. Guy said that there is little difference in the price of four-wheel and six-wheel vehicles; also that the installation of a differential gear between the driving-axles would make the six-wheel vehicle useless for cross-country work. In his experience, users of six-wheel vehicles on hard roads have not wanted to return to the use of four-wheel vehicles.

In discussion submitted by H. L. Horning, reference was made to the strong tendency in the United States toward heavy-freight hauling by motor-truck up to distances of 200 miles. At the same time that overloading and increase in tonnage per trip have grown, there has been great demand for higher speeds. The six-wheel truck, with trailer, has advanced in use, six-cylinder engines of 4½-in. bore and 5¾-in. stroke replacing engines of fewer cylinders and lower speed. The requirements today demand engines of 75 to 85 hp. at 1000 r.p.m. and 140 to 150 hp. at 1800 and 2000 r.p.m.

In replying to the discussion, Captain Kuhne said that a nucleus of standard government vehicles for emergency use in war would become obsolete too quickly, and therefore would not be feasible. He felt that better results could be had by the government from working with the vehicle manufacturers in the production of commercial equipment, as advocated in his paper.

Road-Traffic Conference

At the road-traffic conference held by the Commercial Motor Users' Association, Major-General Long submitted a paper on Road-Transport Accounts. General Long is president of the Mansion House Association on Railway and Canal Traffic. He submitted the first portion of the accounts used by his own firm, stating that they are the result of some 10 years of study, alteration and amendment from time to time in view of experience or information gleaned by comparison with accounts of other firms. In connection with the fact that he did not include overhead in running cost, he said that this is logical inasmuch as overhead is a very variable quantity, depending entirely on the methods used. In the case of pure haulage companies, naturally the whole of such cost would be included, whereas in the case of a manufacturing firm, what is included in the overhead of the transport section is purely a matter for the decision of the directors of the whole busi-

ness. Therefore, if overhead is left out, the question of comparison with other firms becomes a simple matter, as the costs shown are constants, common to all.

Cooperative Deliveries Thought Impracticable

At the meeting of the Incorporated Association of Retail Distributors, an extended discussion was had on the subject of cooperative deliveries in outlying areas in the London metropolitan section. Col. E. Watts Allen, of the Civil Service Supply Association, Ltd., presided. The view of the majority at the meeting was that the establishing of a cooperative delivery service is not practicable at present. The leading department-store and other firms maintaining large fleets of motor-vehicles were represented at the meeting. J. G. Wall, of Harrods, Ltd., was of the opinion that only a relatively few of the large stores would find their trade suitable for a scheme of centralized delivery. Col. A. Jerrett, of Lewis's, Ltd., Liverpool, believed that no really satisfactory delivery system could be completely effective unless the store concerned carried it out with its own personnel.

Anniversary Dinner of Institution of Automobile Engineers

The twenty-first anniversary dinner of the Institution of Automobile Engineers was a very noteworthy affair. More than 500 persons were present, including many ladies. Major E. J. Beaumont, president of the Institution, was in the chair. Addresses were made by Sir Henry Fowler, president of the Institution of Mechanical Engineers; W. J. Tennant, member of the Council of the Institution of Automobile Engineers; and Lieut-Gen. Sir Webb Gilman, master general of the ordnance. Some very good musical and amusing contributions, including the Westminster Abbey Quartette, added much to the event. It was an excellent and thoroughly enjoyed occasion. Many danced. Others renewed acquaintance and found new friends.

The officers and committeemen of the Institution of Automobile Engineers and of the Society of Motor Manufacturers and Traders were most hospitable and kind to the visiting American guests. Many thanks and much gratitude are due them.

Excellent Program for Annual Meeting

Book-Cadillac to Be Society Headquarters Jan. 24 to 27—Meetings Bulletin to Give Final Program

In the first issue of the *Meetings Bulletin* which listed the papers to be presented at the Annual Meeting, a form requesting preprints of the papers when available was included. Keen interest in the technical program is indicated by the receipt of requests for more than 1500 copies of the papers. The large number of requests also proves the desire of the members to study the papers in advance of the meeting so that they will be better prepared to discuss them at the sessions.

Preprints of the papers may be obtained from Society Headquarters on written request. A limited supply of copies will also be available at the Detroit Section office. On the morning of the first day of the meeting, copies of papers for all sessions will be available.

The technical program for the Annual Meeting is given in full on the opposite page. Although this is not final, any changes will doubtless consist of additional papers, business conditions preventing final acceptance by some of those invited by the Meetings Committee to speak at the meeting. It is hoped, for instance, that it will be possible for one of the most prominent English automobile engineers to discuss English and Continental chassis developments and tendencies. The final program will be announced in the *Meetings Bulletin* to be mailed Jan. 15.

No Papers to Be Read in Full

Although four papers have been scheduled for some of the sessions, ample time will be allowed for discussion of all of the papers as none will be read in full. Authors will be limited to from 10 to 15 min., thus allowing from 30 to 45 min. for general discussion of each paper. No discussor will be allowed more than 5 min.; while written discussion may be submitted for publication in The Journal, only a 5-min. discussion may be given orally.

It is felt by the Meetings Committee that pre-printing of papers and limiting presentation and discussion to 15 and 5 min. respectively will make the sessions of much more value and of greater interest to the members.

Sessions Conferences

Breakfast, luncheon and dinner conferences will precede each session for the purpose of bringing together informally the chairman and speakers, as well as members who submit written discussion prior to the sessions. Definite time-schedules will be decided upon at these conferences.

Holding the Annual Meeting at the Book-Cadillac brings to an end the series of Annual Meetings held at the General Motors Building since 1924 and, prior to then, at the Engineering Societies Building in New York City. A hotel offers many advantages that it is impossible to obtain in any office building, even with the many facilities at the General Motors Building. It is hoped that the Book-Cadillac will prove in fact, as well as in name, the headquarters of the Society from Jan. 24 to 27. The personal contacts established at the Annual Meetings are of inestimable value. To further social intercourse, buffet lunches will be served following each of the evening sessions.

The Diesel-Engine Session

If the requests for preprints of the various papers are any criterion, the High-Speed Diesel-Engine Session will be one of the most interesting. Five papers are to be presented at this session, which will be presided over by Prof. C. A. Norman, of the Ohio State University.

The first paper on the program is by O. D. Treiber, of the Treiber Diesel Engine Corporation. This paper admirably states the case of the Diesel engine as a competitor of the carbureting engine in small cylinder-bores. Mr. Treiber points out some of the inherent difficulties and limitations of the injection engine that stand in the way of obtaining light weight, and the theoretical limitations as to mean effective pressure and fuel economy. He considers that the high-speed Diesel engine is limited, at this time, by the time lag of ignition. All of these factors must be mastered before the injection engine, commonly known as the Diesel engine, will be a possibility for automotive applications.

Mr. Treiber's paper may be regarded as outlining the difficulties that must be overcome by the Diesel-engine manufacturers, of which Mr. Treiber's company is one of the most important in this Country, before the Diesel engine can be seriously considered for automotive uses.

The other papers to be presented at the session take the opposite viewpoint of the Diesel-engine situation, presenting results of experimental work in high-speed Diesel-engine design which is thought to approach automotive requirements. Possibly the most interesting of these is R. J.

The 1928 Annual Meeting Technical Program

Book-Cadillac, Detroit

Tuesday, Jan. 24

10:00 A. M.—REGISTRATION

Preprints of Papers Available

2:00 P. M.—STOCK-CAR CONTEST SESSION

A. W. Herrington, *Chairman*

Symposium by F. E. Moskovics, of the Stutz Motor Car Co.; D. G. Roos, of the Studebaker Corporation of America; T. J. Lítle, Jr., of the Marmon Motor Car Co.; H. C. Snow, of the Auburn Automobile Co.; Paul Dumas, of the Chilton Class Journal Co.; James Crawford, of the Chevrolet Motor Co.; and Charles Crawford, of the Stutz Motor Car Co.

7:30 P. M.—BUSINESS SESSION

John H. Hunt, *Presiding*

Reports of Committees

Election of three members-at-large of Nominating Committee

8:00 P. M.—GENERAL SESSION

John H. Hunt, *Chairman*

The Future of Aeronautics—A. H. G. Fokker, of the Fokker Aircraft Corporation

Motion Pictures of the 1927 Summer Meeting and of Quebec

Buffet Supper

Wednesday, Jan. 25

10:00 A. M.—TIRE-SIMPLIFICATION SESSION

C. B. Whittelsey, *Chairman*

Symposium by executives of tire and automobile companies, dealers and others on Need for Simplifying Balloon-Tire Sizes

1:00 P. M.—STANDARDS SESSION

Karl L. Herrmann, *Chairman*

1:30—Committee Reports

2:30—Shall the S.A.E. Steel Physical-Property Charts be Continued?—Discussion by H. T. Chandler, of the Vanadium Corporation of America

3:00—Importance of Car and Oil Manufacturers Specifying Oils by S.A.E. Viscosity Numbers—Discussion by E. W. Upham, of the Chrysler Corporation

3:30—Report of Tire and Rim Division—H. M. Crane, Chairman

Committee Reports

8:00 P. M.—ENGINE SESSION

W. G. Wall, *Chairman*

The Advantages of the Fuel-Feed Pump—A. M. Babitch, of the A C Spark Plug Co.

A Study of Heat-Flow in Aluminum-Alloy Pistons—H. A. Huebotter, of the Butler Mfg. Co.

Some Aspects of Supercharging—C. Fayette Taylor and L. Morgan Porter, of the Massachusetts Institute of Technology

Advantages of Multiple Ignition—H. M. Jacklin, of Purdue University

Thursday, Jan. 26

RESEARCH SESSION

10:00 A. M.—MORNING PROGRAM

S. W. Sparrow, *Chairman*

The Volatility of Gasoline-Air Mixtures—O. C. Bridgeman, of the Bureau of Standards

Results of a Recent Detonation Survey—H. K. Cummings, of the Bureau of Standards

Knock Characteristics of Present-Day Fuels—Neil MacCoull, of the Texas Co.

A Comparison of Methods of Measuring Knock Characteristics of Fuels—Dr. Graham Edgar, of the Ethyl Gasoline Corporation

2:00 P. M.—AFTERNOON PROGRAM

J. A. C. Warner, *Chairman*

Low-Temperature Characteristics of Engine Oils in Relation to Their Performance—R. E. Wilkin, P. T. Oak and D. P. Barnard, 4th, of the Standard Oil Co. of Indiana

Recent Developments in Headlighting Research—H. H. Allen, of the Bureau of Standards

Further Data on Riding-Qualities—R. W. Brown, of the Firestone Tire & Rubber Co.

Application of High-Speed Motion-Pictures to Engineering Development—C. Francis Jenkins, of the Jenkins Laboratories

8:00 P. M.—PRODUCTION SESSION

A. R. Fors, *Chairman*

Research on the Hardness and Machineability of Cast-Iron—T. H. Wickenden, of the International Nickel Co.

Some Fallacies Regarding the Protective Values of Chromium-Plating—E. F. Baker, of the University of Michigan

Die-Rolling of Axles and Other Possible Applications—W. P. Witherow, of the Witherow Steel Co.

Friday, Jan. 27

10:00 A. M.—HIGH-SPEED DIESEL ENGINE SESSION

C. A. Norman, *Chairman*

High-Speed Diesel Engines—O. D. Treiber, of the Treiber Diesel Engine Corporation

Results of Recent American Development Work on the M. A. N. High-Speed Diesel Engine—R. J. Broege, of the Buda Co.

The Development of the Maybach High-Speed Engine—F. W. Von Meister, of the Maybach Motor Co.

High-Speed Automotive Diesel Engines—Dr. Wilhelm Riehm, of Maschinfabrik Augsburg Nürnberg. To be read by R. J. Broege

Industrial Engines—H. L. Horning, of the Waukesha Motor Co.

2:00 P. M.—CHASSIS SESSION

W. R. Strickland, *Chairman*

Independent Springing, Steering and Shimmy—D. Sensaud de Lavaud

Shock-Absorbers from the Car-Manufacturer's Standpoint—N. F. Hadley, of the Chrysler Corporation

New Developments in Brakes—John Sneed, of the Midland Steel Products Co.

8:00 P. M.—BODY SESSION

L. C. Hill, *Chairman*

Advances in Body Painting—Dr. G. C. Given, of E. I. du Pont de Nemours & Co.

Symposium on Body Engineering Problems

(Final Complete Program Will Appear in Jan. 15 Issue of *The Meetings Bulletin*)

Broege's paper discussing the operation of a four-cylinder full-Diesel engine operating in a 4-ton truck in daily commercial service. Mr. Broege will also submit information regarding a large four-cylinder full-Diesel engine in operation in industrial excavator service. Facts to be presented regarding the construction and operating cost of these engines should prove of great interest. Both of the engines he will describe are of the high-speed automotive type designed to replace the automotive-type gasoline engines previously used.

A paper that will prove of equal, if not even more interest, is being prepared by Dr. Riehm, of the Maschinfabrik Augsburg, Nürnberg, Germany. This will discuss the high-speed automotive-type Diesel engine, treating the M. A. N. construction particularly. Dr. Riehm will not be able to come to this Country for the Annual Meeting, but his paper will be presented by Mr. Broege, whose paper deals with the American developments of the M. A. N. engine.

Another informative paper will be presented by F. W. Von Meister, of the Maybach Motor Co., who will discuss the development of the Maybach high-speed Diesel engine that has been used successfully in rail-cars, and which, it is hoped, will ultimately be perfected for use in lighter-than-air craft. Possibly the most important application of the high-speed Diesel engine is for such aircraft, a development that is desirable because of the elimination of the fire risk, fuel oil being non-inflammable as compared with gasoline, and the greater fuel economy making larger useful loads possible.

Slow-Speed Motion Pictures

Two papers to be presented at the Annual Meeting will discuss the use of slow-speed motion pictures in research. These papers are to be given at the Research Session on Thursday afternoon. Dr. C. Francis Jenkins will describe the chronoteine camera which he has developed. The normal speed of this camera is 3200 exposures per second, but speeds up to 9000 exposures per second are possible. The projector slows the rate down to 16 per sec. on the screen. This camera is claimed to be unequaled for the study of many problems in science and engineering, some of which are not possible of accurate determination in any other way.

Obvious applications of this instrument are in the study of airplane propeller and landing-gear action; bursting of balloons and air hose; tire action over obstructions; propagation of flame; engine-valve rebound at high speed; cam-roller jumping; crankshaft whip; brake-shoe and draft-gear applications; in fact, anything that moves too fast for the eye to follow can be slowed down and examined in detail and at leisure.

R. W. Brown's paper on Riding-Qualities is based largely on motion pictures of tires passing over obstructions, taken with the chronoteine camera, the normal rate of speed for the camera being used. Both Mr. Brown and Dr. Jenkins will show actual motion pictures.

Efforts are being made to afford attending members opportunities during the Annual Meeting to witness demonstrations of other instruments used for extending time. Among the instruments that probably will be demonstrated are the stroborama, the stroboscope and the telemeter.

Papers for the Chassis Session

Three papers are scheduled for presentation at the Chassis Session, Friday afternoon, under the chairmanship of W. R. Strickland. The first paper, by D. Sensaud de Lavaud, is on the subject Independent Springing, Steering and Shimmy. Mr. de Lavaud will be unable to attend the Annual Meeting, but the interesting features of design outlined in his paper should prove the basis of a lively discussion.

The second paper will be by N. F. Hadley, of the Chrysler Corporation, who will discuss Shock-Absorbers from the Car-Manufacturer's Standpoint. Mr. Hadley's paper outlines the most desirable type of shock-absorber and describes the various types and the methods of testing employed in determining upon this type. The paper also submits a general statement of what is required of a shock-absorber and describes the construction of an instrument developed for the purpose of measuring the amount and disposal of the energy absorbed by the various types of shock-absorber. The use of this instrument in connection with road-testing is described.

The third paper, by John Sneed, of the Midland Steel Products Co., will be a general discussion of four-wheel brakes with special reference to the method of braking which he has developed and which has recently been adopted by several automobile companies.

Eight Papers on Research

Eight papers are to be presented at the two-part Research Session on Thursday. The morning session will deal entirely with the fuel problem, on which papers are to be given by O. C. Bridgeman, H. K. Cummings, Graham Edgar and Neil MacCoull.

Mr. Edgar's paper is printed in this issue of The Journal, beginning on p. 41. Written discussion is solicited. Mr. MacCoull's paper outlines the procedure he followed in correlating the antiknock characteristics of fuels. Samples of gasoline were sent to 10 laboratories, which tested them for antiknock values by the various methods preferred by these laboratories. An analysis of the data proves that it is possible to correlate data obtained by different methods in different laboratories and to express the results in any way preferred. The paper also includes some general observations regarding the antiknock values of fuels.

The paper to be presented by Mr. Bridgeman deals with the effort being made to correlate the A.S.T.M. Distillation Curve with volatility as measured approximately under manifold conditions. The paper that was presented by Dr. C. S. Cragoe and J. O. Eisinger at the 1927 Annual Meeting and printed in the March issue of The Journal, p. 353, covered the correlation of the 5 and 15-per cent points under the A.S.T.M. Distillation Curve with the volatility requirements for starting engines. Since that time the investigation has been extended to cover the relationship existing over the entire volatility range.

Mr. Cummings' paper will deal with two phases of detonation research. The first is the actual measurement of the detonation characteristics of engine fuels. Two surveys have been made: the first, of gasoline as produced by refiners; the second, of the fuels available to motorists in various parts of the Country. The results of both these surveys will be given. The second part of Mr. Cummings' paper, which supplements material presented by him at the 1927 Annual Meeting, and printed in the May issue of The Journal, p. 599, gives information on additional methods of measuring detonation, concerning which information has become available since the preparation of his former paper.

At the afternoon session, H. H. Allen will make a preliminary report on the headlighting research being carried out at the Bureau of Standards under the technical direction of the Research Committee of the Society with funds provided by the National Automobile Chamber of Commerce. The purpose of the investigation is the determination, by experimental methods, of a standard of highway illumination with head-lamps. The method being pursued is one by which definite data may be obtained as to the kind, type and intensity of illumination that will show plainly objects on or at the side of the road while driving, both with and without approaching lights. The conclusions to be drawn from these data will be of great benefit to the automobile public and will serve as a basis for the elimination of one of the causes of sales resistance with which the car manufacturer now has to cope.

(Continued on p. 108)

The Human Element in Research

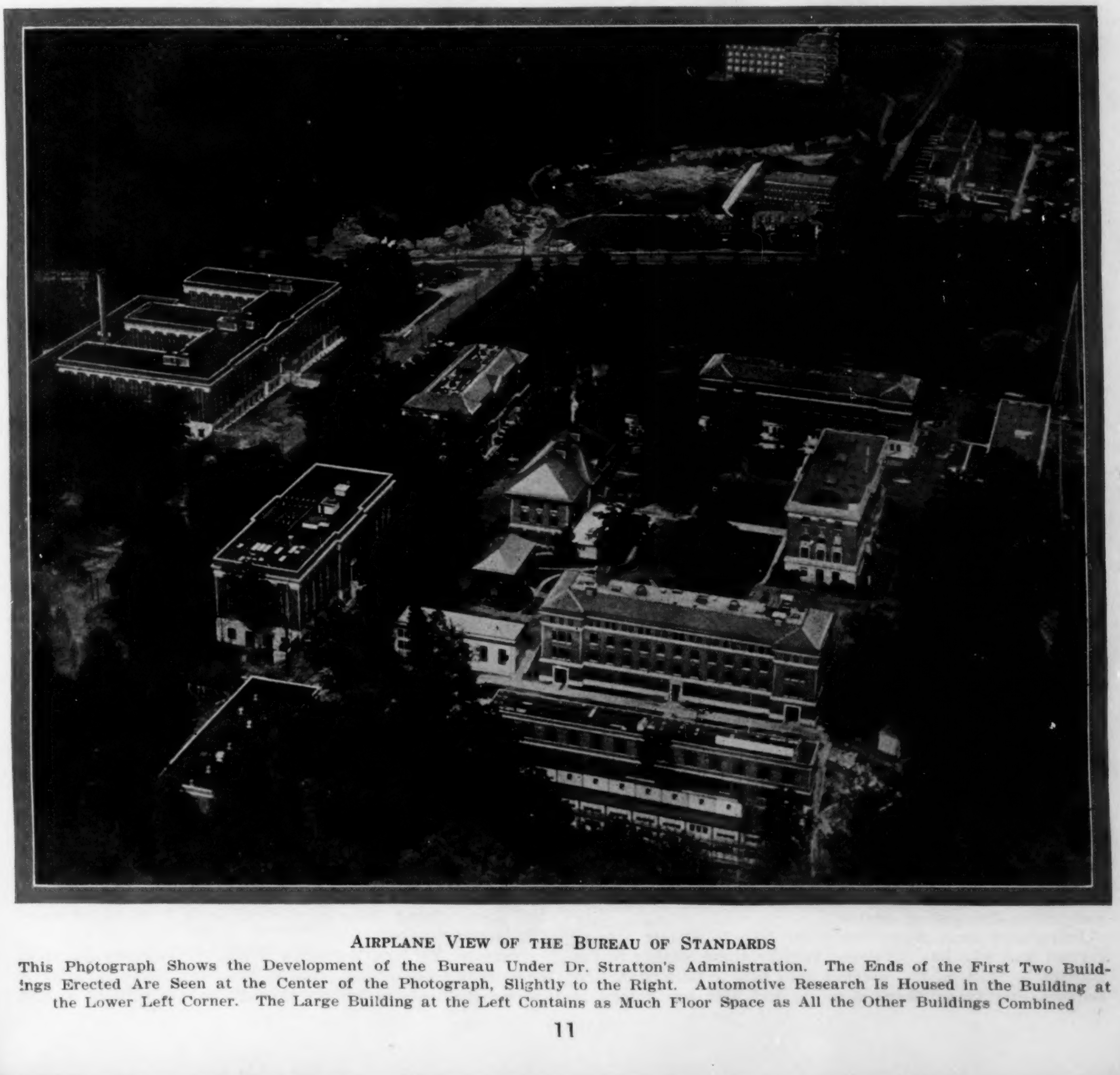
Metropolitan Section Hears Dr. Dickinson Tell of the Man Behind the Test Tube

Meeting on Nov. 29 at the Woodstock Hotel, the Metropolitan Section listened to Dr. H. C. Dickinson, of the Bureau of Standards, while he told of the men who had been responsible for much research work of the Bureau that has benefited the automotive industry. The meeting had been postponed from the regular date because the speaker originally scheduled had been unable to meet the engagement.

Dinner was followed by a business session at which Sidney R. Dresser was elected member and George Round alternate for the Nominating Committee for officers of the Society, and the following were elected as a nominating committee for officers of the Metropolitan Section: A. M. Welch, William Kemp, David Beecroft, Charles Drumm, and Grosvenor Hotchkiss. The chairman of the Section, E. F. Lowe, was elected as Metropolitan Section representative on the Sections Committee of the Society.

Dr. Dickinson said that all of us are researchers in one way or another and that the subject may be divided into three classifications: pure science research, industrial research, and trouble shooting. Whatever work is accomplished is the product of some brain. We are inclined to overestimate the material factors and obscure the importance of the head.

To show the personal element in research at the Bureau of Standards, Dr. Dickinson made use of two stereopticons,



AIRPLANE VIEW OF THE BUREAU OF STANDARDS

This Photograph Shows the Development of the Bureau Under Dr. Stratton's Administration. The Ends of the First Two Buildings Erected Are Seen at the Center of the Photograph, Slightly to the Right. Automotive Research Is Housed in the Building at the Lower Left Corner. The Large Building at the Left Contains as Much Floor Space as All the Other Buildings Combined

showing on one half of the screen the face of a research man and on the other half successive illustrations of work that he had accomplished.

The First Director of the Bureau

Dr. S. W. Stratton, whose picture appeared first, showed remarkable genius in mechanical lines during his humble boyhood. When called to be the first director of the Bureau of Standards, in 1901, he was professor of physics and mathematics in the University of Chicago. At that time the staff of the Bureau numbered about 20 people. When he resigned to become president of the Massachusetts Institute of Technology, in 1923, the Bureau had a staff of 800 or 900. The physical growth of the Bureau during this time was indicated by two photographs, one showing the buildings that existed in 1907 and the other an airplane view taken at the time of Dr. Stratton's resignation. The latter is reproduced herewith. The conception and development of this institution as a great laboratory was ascribed largely to the constructive vision of Dr. Stratton.

Among the activities of the Bureau that were represented by slides projected opposite Dr. Stratton's picture were a paper mill, work with which has resulted in the production of new material for paper currency; a textile mill; a laboratory for testing volumetric glassware; and the laboratory for testing aircraft engines under altitude conditions, with which members of the Society are familiar.

Dr. G. K. Burgess, whose face followed Dr. Stratton's on the screen, came to the Bureau as a member of the staff in 1903. He was educated in France, was professor in two or three American universities, and succeeded Dr. Stratton as chief of the Bureau. Although the Bureau has not had the opportunity to make such spectacular strides under Dr. Burgess as in its earlier history, Dr. Dickinson paid tribute to him as a man of very profound learning and real accomplishment under difficulties, as well as a delightful co-worker. Apparatus shown opposite Dr. Burgess's picture included an early model of the air-inductor compass now used on airplanes; two views of equipment for testing the life and rolling efficiency of automobile tires, and head-lamp testing equipment.

Next was shown a picture of Dr. C. W. Weidner, formerly chief of the Division of Heat and Power, to whom Dr. Dickinson, who is now chief of the same Division, paid a warm personal tribute. Dr. Weidner was quoted as saying that, if a thing has happened a million times, that is no proof that it will happen the next time unless the reasons are known.

The Rise of an Apprentice

A face familiar to S.A.E. men was shown next, that of W. S. James, whose physician father left him an orphan at an early age. He came to the Bureau as an apprentice about 1910. His education was acquired at George Washington University while he was working at the Bureau. One of the photographs shown in connection with Mr. James was of the altitude testing laboratory, in the building of which he assisted. Work that he directed there resulted in better fuel for aircraft and in other improvements. Further photographs of Mr. James's work showed a test car provided with means for making correct records of as many as 16 elements of its performance; a closer view of the recording elements of the same car, which make a continuous photographic record of the gasoline consumption, acceleration and deceleration, manifold air consumption, water circulation, air velocity, and temperature at a number of points; and a decelerometer which now is sold commercially and is used by law-enforcement authorities for testing brakes.

Introduced as a New Englander who is almost always correct and who has developed rapidly since coming to the Bureau in 1918, S. W. Sparrow was said to be a man who finishes everything there is to do and who has helped in even more work that is credited to other men than has appeared under his own name.

Opposite Mr. Sparrow's picture was shown a balanced-diaphragm inductor for measuring instantaneous pressures in the engine cylinder. The device is screwed into the spark-plug hole with pressure from the cylinder on one side and applied pressure on the other side of a sensitive diaphragm. The diaphragm actuates an electrical contact which is combined with a timer having a very short period. By varying the point in the cycle at which the timer contacts, at the same time varying the pressure applied to the diaphragm, a most precise measure of the cylinder pressure throughout the cycle has been obtained.

In studying the formation of carbon in engine cylinders, Mr. Sparrow made a very simple experiment. He applied the flame of a Bunsen burner to one end of an iron rod so that the temperature of the rod varied from 212 deg. fahr. at one end to a dull red at the other end. He then dripped oil uniformly along the rod, with the result that carbon formed midway of the length of the rod. This carbon formation occurred only at the part where the temperature range was between 550 and 400 deg. fahr. This seems to indicate that, if the temperature of the entire surface of the combustion space of an engine could be kept outside that temperature range, no carbon would be deposited. A photograph of this rod with its carbon encrustations was shown.

Another carbon demonstration was made by Mr. Sparrow, said Dr. Dickinson. An engine was run for a few hours at about half load with a rich mixture and a little too much oil. The cylinder-head was removed and a photograph, which was shown, made the carbon formation very evident. The cylinder-head was replaced without removing any carbon and the engine was run for 4 or 5 hr. at three-quarters load with a moderately lean mixture and proper oil supply. Another photograph showed that the carbon deposit had disappeared and demonstrated the difficulty of proving or disproving claims for carbon removers.

A Light That Shines No More

Born in the South and educated at Penn State College, T. S. Sligh, Jr., came to the Bureau about 15 years ago. Dr. Dickinson said that Mr. Sligh always enjoyed solving a difficult mechanical problem and could accomplish more with a can, a spool and a string than could most laboratory men with an entire machine-shop. Instances of the work of Mr. Sligh, as shown on the screen, included apparatus for testing oil under oxidizing conditions, a distillation flask for studying oil dilution, and apparatus connected with the distillation of gasoline, including a pipette for measuring a very minute quantity of fuel with extreme accuracy.

At the present time, H. K. Cummings is in charge of the section dealing with automotive powerplants. He is a Scotchman who has been with the Bureau for 7 or 8 years. Opposite his photograph were shown a layout for testing the anti-knock properties of engines and fuels, and a bomb with an indicator consisting of a steel ball resting on a flexible steel plate. When detonation occurs the steel ball is thrown into the air. A test of the corrosive properties of anti-freeze solutions was also shown.

In connection with S. von Ammon, whose portrait was shown next, was related an instance of accomplishment under peculiar conditions. After an explosion had damaged much equipment at the Bureau and made necessary a provision of safety devices, Congress granted funds for its restoration. The appropriation became available in April and had to be spent before July 1. Although the job included the erecting of three buildings and providing much minor equipment, Mr. von Ammon got the work done and accomplished twice as much as could be expected under the circumstances.

Some of Mr. von Ammon's work, photographs of which were shown beside his picture, has been made familiar to the members of the Society through papers printed in THE

BUREAU OF STANDARDS RESEARCH MEN

The Metropolitan Section Speaker and the Research Men Whose Pictures Were Shown at the Meeting in Connection with Work that They Have Accomplished. All of Them Are or Have Been Connected with the Bureau of Standards

Dr. S. W. Stratton	Dr. G. K. Burgess	William S. James
Dr. Stanwood W. Sparrow	Dr. H. C. Dickinson	Tom S. Sligh, Jr.
H. K. Cummings	S. von Ammon	H. H. Allen

JOURNAL, including elaborate dynamometer equipment for testing truck axles and methods of testing brake linings.

A Harvard graduate of colonial ancestry is M. D. Hersey, who was next shown on the screen. He has a brilliant mind and has been connected with the Bureau of Standards for many years, with an interlude during which he taught at the Massachusetts Institute of Technology and then was connected with the Bureau of Mines.

Mr. Hersey's work is not directly connected with the automotive industry but an interesting journal-friction testing machine of his design was shown by the speaker. This machine is made largely from automobile engine connecting-rods and makes possible a very accurate determination of friction in about 1/20 of the time required by an elaborate machine costing 100 times as much. In use, the shaft of this machine is mounted in a lathe.

Hear Him at the Annual Meeting

The last portrait to be shown on the screen was that of H. H. Allen, who is continuing the work on brake testing that was started by Mr. James. Mr. Allen has extended this to include a study of the time required by a driver to apply the brakes after a warning. A lantern slide showed the car used for this work, under the running board of which are mounted two revolvers loaded with red lead. By means of a string attached to the trigger, the observer fires one revolver when the car is at the desired speed. This makes a red spot on the pavement. The second revolver is fired automatically when the brake is applied and the distance between the two red spots measures the driver's reaction time. This is about ½ sec. with the ordinary good driver and represents a considerable distance when driving at 30 m.p.h. The time required increases slightly with the age and decreases with the experience of the driver. The shortest times, between 0.2 and 0.3 sec., were recorded with taxicab drivers, and the longest times were nearly 1.5 sec. with particularly unadaptable people.

A chart prepared by Mr. Allen was shown which gave results of many observations of the brake action of cars as they were found in different cities and recorded by the decelerometer. He has been largely responsible for drafting the proposed safety code for brakes, which has been approved by the American Engineering Standards Committee and is being adopted by a number of cities and States.

Another slide showed a car with which Mr. Allen now is working on features of head-lamp performance. About a month was spent in taking observations of the distance at which a visibility target corresponding to the size of a man could be seen with various degrees of illumination and various weather conditions. Then two cars were equipped with four head-lamps each and about 40 lenses that can be arranged to secure any desired light distribution. One of these outfits was put on the rear of a car. The procedure is to stop this car some distance ahead of the other car. The driver in front swings out a target that is fastened to a door and the driver behind approaches until he sees this target, the rear head-lamps of the forward car being dark. After the distance between the cars has been measured, the rear head-lamps of the forward car are turned on and the driver of the rear car repeats the procedure under new conditions. In this way, 200 or 300 observations can be made in one night, many more than could be made if it were necessary to turn the cars to face each other for each observation. This work is not yet completed and the results of it, therefore, are not available.

Facts About Oils and Fuels

Lubrication Troubles, Possible Fuel Sources and Standard Hydrocarbons for Rating Fuels Reviewed in Boston

Many interesting points about lubrication and fuels were presented at the meeting of the New England Section held on Dec. 7. Lubrication was treated by George A. Round, of the Vacuum Oil Co., and data on fuels were presented in two papers, one by Prof. W. H. McAdams, of the Massachusetts Institute of Technology, and the other by Dr. George Calingaert, assistant director of research for the Ethyl Gasoline Corporation. The meeting was held at the Engineers Club, Boston, and a dinner preceded the technical session.

Blackening of the oil in service was said by Mr. Round to be one of the most common troubles about which complaints are received. He remarked that many times this blackening is considered a measure of the value of the lubricating oil. To a certain extent this is true, and to a certain extent it is not true. To illustrate this point, Mr. Round showed various lantern slides to demonstrate the fact that a considerable quantity of material which causes the oil to become black is soft and plastic instead of being hard and abrasive to an extent that is harmful to an engine.

Much research work has been done during the last 18 months, he said, to determine why and how this black material forms in oil, why some oils become black faster than other oils do, and why they stay black. The equipment used in this determination was a modern high-power high-speed fast-running engine equipped with a filter and an oil-rectifier but not equipped with an air-cleaner. One of the results of the investigation was to prove that part of the black material is oil which has broken down. When any oil is subjected to heat in the presence of air it becomes oxidized and acts somewhat in the same manner as does linseed oil when used in paint; as it oxidizes it becomes thicker. As the process is continued, petroleum acids are formed which act on the oil and form a sludge of carbonaceous matter which is plastic. The rate of formation of the black material depends on the heat condition in the engine and the amounts of oxygen and air fed through the crankcase. In an engine which becomes hot it forms in a considerably greater amount than in an engine that is slightly heated. In other words, there is a greater difference in the quantity of black material formed due to engine design and construction than there is due to difference in the oil used. However, some very marked differences do exist in the lubricating oil, and the speaker illustrated by slides what these differences are.

Silica, a constituent of road dust, does most of its damage in the engine before it reaches the oil, and Mr. Round showed views of various types of air-cleaner designed to filter dust from the air used by the engine. He also showed various types of oil-filter for eliminating foreign material which enters the oil. He mentioned the fact that, unfortunately, after filters of any sort have been installed, they become clogged and that all too frequently they are operated in the clogged condition and are not cleaned, which makes them useless.

After outlining the troubles caused by dilution, Mr. Round showed views of various oil-rectifiers in common use and commented upon their several efficiencies. Other problems which the speaker outlined and discussed were the formation of sludge, formation of water in the crankcase, corrosion due to constituents of the various fuels, and problems related to crankcase drainage.

(*Continued on p.* 129)

Chronicle and Comment

The Annual Dinner

AT the rate at which reservations for the Annual Dinner at the Astor on Jan. 12 are being received, the attendance will exceed that of recent years. An excellent program has been arranged that will, as in previous years, assure the Dinner being the outstanding automotive event of the year. The principal speakers will be President Ralph Budd, of the Great Northern Railway, who will discuss the place of the automobile in transportation, and J. Walter Drake, who will discuss engineering leadership in industrial progress.

Need for Revising the S.A.E. Steel Charts

THE purpose of the Iron and Steel Division in undertaking a comprehensive revision of the S.A.E. Physical-Property Charts is admirably outlined by H. T. Chandler in his splendid explanation, submitted as discussion of E. J. Janitzky's paper on Correlating Test-Data on Heat-Treated Chromium Vanadium Steels, appearing on p. 55 of this issue.

Everyone who has any occasion to use the S.A.E. Physical-Property Charts should study this paper and the discussion, both oral and contributed. The revisions proposed involve a tremendous amount of work and it should not be undertaken without the full knowledge and support of industry.

Automotive Design Tendencies

CAREFULLY founded, well-visioned analyses of automotive design-tendencies always furnish interesting reading. Of special appeal is an article of this type prepared by Austin M. Wolf for the American Year Book, reviewing the developments that marked 1927 motor-vehicle history. Those who heard Mr. Wolf's talk at the Metropolitan Section meeting last January summarizing the prominent features of models exhibited at the Automobile Show, or read the article incorporating it in the February, 1927, issue of THE JOURNAL, know the masterly thoroughness with which he handles a task of this kind. In this second article he has again assembled a mass of critical comment on the multitudinous details that go to make up a modern car. A student of automotive design for many years, Mr. Wolf is adept in distinguishing the new from the recurrent, fad from tendency and the essential points that require emphasis.

Nominating Committee to Meet in January

AS a result of the revision of that part of the Constitution relating to the election of the Annual Nominating Committee, the Committee will be able to hold its first meeting during the Annual Meeting instead of in conjunction with the Summer Meeting. It will, in fact, be possible for the Committee to hold several meetings during the Annual and the Summer Meetings and to give more thorough consideration to the important problems before it than has been possible heretofore by the Nominating Committee.

The Annual Nominating Committee consists of one member from and elected by each of the Sections and three members-at-large elected at the Annual Meeting. Every Section but one has elected its representative on the Committee for 1928. The present personnel is: Donald Cox, Lee Oldfield, Eugene Bouton, Rodger J. Emmert, W. T. Fishleigh, Dan Teetor, Sidney Dresser, John J. Balsom, Albert Lodge, B. B. Bachman, William M. Britton, and A. W. Herrington.

Transportation

PRODUCTION of raw materials, manufacturing, and distribution are the three major activities of civilized man. With the progress of invention, distribution has come to be of equal importance with such production and with manufacture. Transportation enters largely into all three activities and is today one of the greatest general industries in all progressive countries.

The advantages of mass production, of both raw and finished products, have been gained at the expense of increased transportation for Country-wide distribution. For a generation there has been a continuous and rapid increase in population and in per capita transportation, with no proportional expansion of railroads and waterways of the Country. This has resulted in congestion of the transportation facilities, especially at railroad terminals and in ports, where expansion of transshipping facilities is both difficult and excessively costly.

The existing condition in large cities and at freight terminals presents one of the greatest problems confronting the Country and is a direct challenge to transportation engineers. Extraordinary progress has been made in reducing the man-hours of labor required to produce a given quantity of food or other raw materials and to convert them into finished products by manufacturing processes. Similarly, great progress has been made in reducing the hours of labor required to transport these raw and finished products through developments in rail and water vehicles and systems of transport.

High cost of distribution, nevertheless, is today probably the greatest impediment to further increase in National prosperity and all that it involves; and handling and highway transportation are major elements in distribution. Thus the remaining big opportunity for effecting economy seems to lie in betterment of highway transportation and of handling systems at rail and water shipping points.

This is a problem upon the solution of which the best brains of rail, water and highway transportation men can well be concentrated in closest cooperation. It is highly encouraging, therefore, to see such a spirit of cooperation and so much attention given to the subject of transport coordination as was evident at the Transportation Meeting in Chicago and at the World Motor-Transport Congress. All advances made in lowering handling costs at terminals and in hauling by highway must help to promote National prosperity by reducing living costs and increasing consumption and production and must benefit all the carriers through increases in the volume of shipping.

Personal Notes of the Members

Foulois Becomes Assistant Chief of Air Service

Lieut-Col. Benjamin D. Foulois was sworn in as Assistant Chief of the Air Service on Dec. 14, 1927, in the City of Washington. With this appointment, he received the grade of Brigadier General, succeeding Brigadier-Gen. James E. Fechet, who, with the rank of Major General, has been appointed to the post of Chief of the Air Service which was made vacant by the retirement of Major-Gen. Mason M. Patrick.

Brigadier-General Foulois' connection with aeronautic affairs dates back to 1908, the year which marks the beginnings of aviation in the United States Army. During the early days of aeronautics, he was a pioneer, gaining in various phases of the work a distinction which has been augmented by his subsequent achievements. He was one of three men, the others being Lieut. F. P. Lahm and Lieut. T. Selfridge, to operate the first Army dirigible balloon and the first military airplane in the Army. In 1909 he was an observer with Orville Wright on the first cross-country airplane flight made in the United States. At one time he was, for a period of more than a year, the only officer in the Army on flying duty. He is noted for having designed the first set of wheels used on a Wright airplane in this Country, as well as for having designed the first airplane radio sending-set ever used on an airplane in the United States Army. In 1914 he organized, equipped and trained the first aero squadron, and in 1916 he commanded the first aero squadron in Mexico.

His war activities are too numerous for detailed treatment here. Mention should be made, however, of the fact that he was Chief of Air Service, A.E.F., from November, 1917, to May, 1918, and Chief of the Air Service, 1st Army, from May, 1918, to July, 1918. Being relieved of this latter duty at his own request, he was made Assistant Chief of Air Service, Zone of Advance, until October, 1918, from which time until June, 1919, he was Assistant Chief of Air Service (Service of Supplies).

In 1920 he became Assistant Military Attaché for Aviation, at Berlin, Germany, where he remained for 4 years. For some time prior to his appointment as Assistant Chief of Air Service, Lieutenant-Colonel Foulois was commanding officer at Mitchel Field, Long Island, N. Y.

The Society is honored in having as a member Brigadier-General Foulois, who was elected Associate Member on Oct. 23, 1925.

Ray M. Hudson Promoted

Ray M. Hudson is now assistant director of commercial standards for the Bureau of Standards, Department of Commerce, City of Washington. He was formerly chief of the Division of Simplified Practice of that Bureau.

After his graduation from Syracuse University in 1908, with a degree in mechanical engineering, Mr. Hudson worked for a few months as automobile mechanic with a contracting company engaged in road building. Early in 1909 he assumed the duties of lathe operator in the machine-shops of the H. H. Franklin Mfg. Co., in whose service he remained until 1918, holding the following positions: assistant in the experimental laboratory, technical correspondent, traveling engineer, service superintendent, and employment superintendent and assistant to production manager.

From February, 1918, until April, 1919, Mr. Hudson was connected with the Emergency Fleet Corporation, first as production expediter, next as assistant to the manager of the supply division, and then as supervisor of the schedules and requirements section of the supply division.

Returning to commercial work in 1919, he accepted a position with the Holt Mfg. Co., Inc., where he remained until the end of 1921, first in the capacity of manager of methods and personnel, and later as acting research engineer.

On Jan. 3, 1922, Mr. Hudson became assistant chief of the division of simplified practice of the Department of Commerce, and was later made chief of this division, the major function of which is the elimination of waste in industry through simplification and standardization.

Technical and trade magazines during the last 10 years have published a number of contributions by Mr. Hudson. An article on the cost of living in relation to wage adjustments, which appeared in *Industrial Management*, September, 1918, covered an investigation at the Franklin plant; a similar study in the *Bulletin of the Taylor Society*, October, 1919, was based on an investigation at the Holt plant. A Fair Day's Pay for a Fair Day's Work was published in March, 1922, in *The Annals of the American Academy of Political and Social Science*. His later articles, dealing with simplified practice, are too numerous for specific mention here. He was called upon by the Encyclopaedia Britannica to prepare the section dealing with simplification and standardization in its new edition.

Mr. Hudson is a member of the Taylor Society, well-known pioneer in the movement for better business management, and also of the National Street and Highway Safety Conference Committee on Uniform Traffic Regulations; the National Distribution Conference Committee on Expenses of Doing Business; the American Engineering Council's Committee on a Five Year Research Program; the Society of Industrial Engineers' Committee on Waste Elimination; the National Research Council Committee on Industrial Lighting; the National Committee on Wood Utilization; the National Committee on Metals Utilization, and other important committees.

Mr. Hudson as well as the work of his Division was accorded signal recognition through his appointment as Secretary of the National Committee on Management Week for 1926, and for 1927. This appointment carried with it the responsibility of actually directing the organization of Management Week activities throughout the country. The sponsoring organizations were the American Society of Mechanical Engineers, American Management Association, American Institute of Accountants, Society of Industrial Engineers, Taylor Society, National Association of Purchasing Agents, National Association of Foremen, Life Office Management Association, National Association of Office Managers, and the Division of Simplified Practice of the Department of Commerce.

Mr. Hudson has been active in the work of the Society since his election to Member grade in 1923. He is a member of the Washington Section of the Society.

Hunsaker Made Assistant Vice-President

Jerome C. Hunsaker was made assistant vice-president of the Bell Telephone Laboratories, Inc., New York City, on Nov. 1, 1927. He has been in the employ of this company since Nov. 1, 1926, having resigned his commission as commander in the Construction Corps of the Navy at that time.

Mr. Hunsaker was educated at the United States Naval Academy and the Massachusetts Institute of Technology, from the latter of which he received the degree of master of science in 1912 and doctor of science in 1916. In 1913 he was sent to Europe by the Navy Department to investigate the state of the art of aviation. He was employed for short periods in the aerodynamical laboratory of the

(Continued on p. 18 of the advertising section)

BRIGADIER-GEN. BENJAMIN D. FOULOIS

Notes and Reviews

This column, which is prepared by the Research Department, gives brief items regarding technical books and articles on automotive subjects. As a general rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J, Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor. *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

AIRCRAFT

Aviation. By F. Handley Page. Published in *The Journal of the Royal Aeronautical Society*, November, 1927, p. 1004. [A-1]

"Today, reviewing all the progress which has taken place, no one can say whether the genius of the human race will develop its mechanical transport to such an extent that, old and new worlds conquered and the sea bridged, it will seek a new outlook to its endeavor, by seeking and perhaps succeeding in bridging the vast distances between this earth and the other habitable units of our solar system or whether, having reached a comparative finality in mechanical progress, mankind will rest content with a wireless presentation of voice and features of those who would communicate each with the other, rendering unnecessary that costly transport of the human body which is of little use other than as a containing medium or a directing mind."

With this peroration, the author closes an analysis of present-day aircraft design made with the object of indicating what improvements are likely in the future. These are summarized as a structure weight percentage of not more than 27½ per cent, an n x l/d figure of 10 to 12 at climbing speed and 7 to 8 at top speed, and a fuel consumption not exceeding 0.35 pint per hp-hr. He then reviews the effect that such developments may have on the operation of civil aircraft and makes some comparisons with what is achieved today.

In the course of the article, the author recommends the policies fitted to stimulate progress and pays a tribute to the efficiency of American commercial aircraft.

Modern Aircraft. By Victor W. Pagé. Published by the Norman W. Henley Publishing Co., New York City. 855 pp.; 400 illustrations. [A-3]

To meet the demand for a simple non-technical exposition of airplanes and airplane performance is the object of the present book, which is presented primarily as a guide for instruction work and for general reading by those interested in air transportation. It disclaims any effort to be classed as an engineering treatise or to include in its scope technical points of interest only to the designer.

Some of the basic principles of airplane flight and airfoil design are discussed in simple language. New types of engine are described and directions given for their installation and care. Recently designed airplanes and seaplanes and their principal characteristics are treated. The notes on inspection and the lining up of airplanes are brief and are applicable to airplanes in general; as are the observations on flying. Rather extended consideration is given to some of the aspects of commercial aviation, and notes on aerial navigation and night flying are included.

The author was an aeronautical engineer officer in the Army Air Service in active service both in this Country and abroad. His duties included instructing aviators and mechanics and in connection with this work he has also written a book on airplane powerplants.

CHASSIS PARTS

The Technique of Gear Design. By Henry E. Merritt. Preprint of paper presented before the Institution of Automobile Engineers. Published by the Institution of Automobile Engineers, London, England. 29 pp.; 17 illustrations. [C-1]

Not only is there an almost total lack of authentic data on the design of high-duty gears, the author says, but such methods of design as are used are seldom based on any clear-cut fundamental principles. In a brief reference to the possibility of standardization, he suggests that the best method of procedure would be to build up a scheme from first principles only. In his preliminary discussion he also sets forth an extensive system of notation which is designed for simplicity and ease of use.

A presentation of some of the work that the author has done in an attempt to unify the methods employed in the design of gears of various kinds occupies the major portion of the paper. In an appendix is given an analysis of gearbox and rear-axle stresses in a number of British phaetons.

The Spontan Transmission Gear. Published in *Engineering*, Nov. 18, 1927, p. 658. [C-1]

The new transmission, which has been tested on an 11-hp. Fiat car and was shown at the Commercial Motor Exhibition, Olympia, England, was designed by F. Ljungström, of Aktiebolaget Spontan, Stockholm. It makes possible the control of every operation of a car, except steering, through the movement of a single pedal.

An automatic mechanical transmission gear is incorporated in the design, and while in other similar devices, such as the Constantinesco and the De Lavaud, the continuous action of some form of mechanical valve is involved, the valve of the Spontan transmission comes into operation only during a change of speed or when the car is running on the equivalent of a low-gear ratio.

The principle of the gear is explained by a comparison with a system of three planet wheels mounted on the flywheel of the engine. The sun wheel is attached to the transmission shaft and an unbalanced weight to each planet wheel. In normal direct drive, all of the elements rotate together as a unit; in the condition corresponding to indirect drive, the planet wheels revolve about their own axes, with the unbalanced weights alternately absorbing and giving out the energy of the engine, due to centrifugal force.

In the apparatus as fitted to the Fiat car, the sun and planet wheels are replaced by a system of eccentrics. The mechanical features and operation of this gear are described in detail.

The other feature of the device, the control pedal, holds the brakes full on when in normal position. To release them, the pedal is depressed. At a certain point the brakes are entirely released and the pedal reaches the throttle lever. Further movement opens the throttle to any desired extent.

(Continued on p. 26 of the advertising section)

Automotive Research

INTERPRETATION OF EXHAUST GAS

Writers on internal-combustion-engine performance have, for the most part in the past, treated it as a thermodynamic problem. The author of the accompanying report, Clarke C. Minter[1], concentrates on its physicochemical aspects. Approaching the subject of exhaust-gas analysis from this viewpoint, he set forth in a previous article[2] the simple stoichiometric relations that exist in an ideal system between the products of combustion of a hydrocarbon fuel-air mixture.

The presence of free oxygen in the exhaust gas even where the charge is known to contain fuel in excess, which has been experimentally observed, emphasized the necessity for a more profound consideration of the combustion process. The appearance of the free oxygen is explained by assuming that the charge is not homogeneous, but burns as a mixture of mixtures.

In this article the author pictures the composition of the non-homogeneous charge as a manifestation of the law of probabilities.

Few attempts have ever been made to study systematically the physical chemistry of the internal-combustion engine, for the reason, apparently, that the phenomena are so complex that it seems almost impossible to treat them. In this discussion a very complex subject is going to be still further complicated by the introduction of the theory of probabilities. The only excuse to be offered is that the application of probability seems imperative when due consideration is given to the conditions under which an engine operates. It is not an exaggeration to say that engine performance is a matter of chance, and it is more or less of an accident to find that performance checks predictions, for the reason that we do not know how to predict with accuracy.

During an investigation of the effect of initial conditions of temperature, pressure and concentration on the composition of exhaust gas, it was observed that changes expected on the basis of the water-gas equilibrium being operative did not always occur, or else the expected changes were obscured by unknown causes. It was also observed that free oxygen always occurred in the exhaust from a single cylinder even when the charge was known to contain fuel in excess. It was this fact that suggested the use of probability.

Three possible explanations may be advanced to account for the presence of free oxygen in the exhaust when the fuel is known to be in excess. The first is that the combustion reactions are not completed by the time the exhaust valve opens. The second is that carbon dioxide and water dissociate and do not recombine. The third is that the fuel is not uniformly distributed through the charge, a certain portion of the charge containing air in excess, and that the residue of oxygen passes into the exhaust.

All three effects may be operative to a certain extent. As is well known, the rate of reaction is much slower toward the end of the reaction, and some of the fuel may remain unburnt and some of the oxygen unused by the time the exhaust valve opens. However, free oxygen never occurs in the gases from the inner cone of a gas flame, and the reaction velocities are much slower in the flame than in the engine. We can, accordingly, regard the effect as negligible in the case of the engine.

Dissociation without recombination of the water and CO_2 has been studied by Tizard and Pye[3]. In the first place, the "guessed" temperatures employed by Tizard and Pye are much too high. No such temperatures are ever attained in the engine. And even though the temperatures are high enough for dissociation to become appreciable, there is never any distinct dissociation as such when the fuel is in excess. Since the water-gas equilibrium undoubtedly is operative, the water and CO_2 would be constantly exchanging atoms of oxygen with the aid of the CO and H_2, but there would never be any free oxygen that could be detected analytically. In addition, the high pressures would also suppress any tendency, when the air is in excess, for dissociation to occur. The effect of dissociation can then be neglected.

It remains for us to explain the occurrence of free oxygen in the exhaust by assuming that the charge is not homogeneous and that it burns as a "mixture of mixtures," some parts of which contain air in excess.

If the non-homogeneous charge is a tenable hypothesis, it is highly desirable to express the non-homogeneity in a quantitative manner, and consequently be in a position to predict how much free oxygen is to be found in the exhaust under various conditions. The starting-point for this *a priori* process is the so-called "normal" law of errors, which is assumed to govern the distribution of the fuel throughout the charge.

IDEAL VOLUMES OF THE COMBUSTION PRODUCTS

In this discussion the term "combustion products" is used in a restricted sense and embraces the four products CO_2, CO, H_2O and H_2. It it assumed that no free carbon or hydrocarbons result from the decomposition of the fuel. A set of ideal volume-relations given in a recent communication[4] will be repeated here for convenience.

All calculations are based on the fuel octane, C_8H_{18}, and the fuel is considered to be added to 100 volumes of dry air at 20 deg. cent. (68 deg. fahr.) and 760 mm. (2.99 in.) pressure.

When the fuel is in excess, we have

$$vCO_2 + vCO = 202/R \tag{1}$$

and

$$vH_2O + vH_2 = 227.3/R \tag{2}$$

Here v represents the volume of the gas, and R the air-fuel ratio by weight. For octane we have the relation

$$vH_2O + vH_2 = 1.125(vCO_2 + vCO) \tag{3}$$

When the air is in excess, we have

$$vCO_2 = 202/R \tag{4}$$

and

$$vH_2O = 227.3/R \tag{5}$$

For the volume of the oxygen used we employ the relation

$$vO_2 = vCO_2 + vH_2O/2 \tag{6}$$

These relations were deduced on the assumption that the fuel was uniformly distributed throughout 100 volumes of

[1] Research chemist, New York City.

[2] See THE JOURNAL, November, 1927, p. 573.

[3] See *Engineering*, Sept. 3, 1920, p. 325, and *The Automobile Engineer*, February, 1921, pp. 55, 98, and 134.

[4] See THE JOURNAL, November, 1927, p. 573.

air. It makes no difference how the fuel is distributed, the relations are still valid when applied to an element of volume. The total volume of combustion products is also evidently independent of the distribution, since a definite mass of fuel will yield a definite volume of combustion products; that is, a certain mass of carbon can yield the same volume of CO_2 or CO, and a definite mass of hydrogen gives a corresponding volume of H_2 or H_2O. This fact serves as a check on all calculations based on probability.

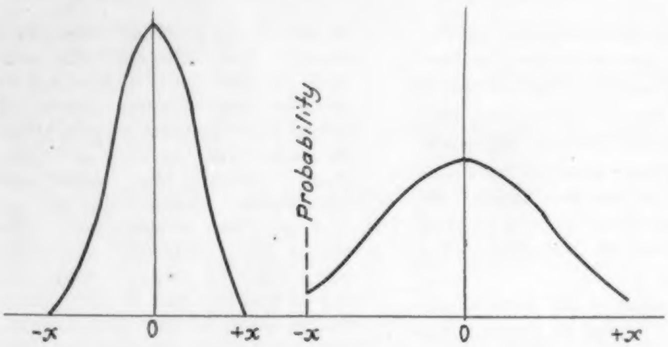


FIG. 1—CURVES SHOWING THE PROBABILITY OF ERROR DEVIATING BY $\pm x$ FROM THE ARITHMETICAL MEAN

The Curve on the Left Represents the Deviations When the Modulus of Precision Is High. The Curve on the Right Shows the Greater Probability of Deviations When the Modulus of Precision Is Lower

In Table 1 the volumes of the combustion products for several ratios are given for convenience. These figures are for octane added to 100 volumes of air under standard conditions.

TABLE 1—VOLUME OF COMBUSTION PRODUCTS FOR SEVERAL AIR-FUEL RATIOS

Air-Fuel Ratio	Octane in 100 Volumes of Air, Grams	vCO_2	vH_2O
20	0.00607	10.05	11.35
19	0.00639	10.65	11.98
18	0.00675	11.21	12.62
17	0.00714	11.87	13.36
16	0.00759	12.61	14.20
		$vCO_2 + vCO$	$vH_2O + vH_2$
15	0.00809	13.46	15.14
14	0.00867	14.43	16.62
13	0.00934	15.53	17.47
12	0.01012	16.82	18.93
11	0.01104	18.31	20.65
10	0.01214	20.18	22.71
9	0.01349	22.43	25.23
8	0.01518	25.24	28.39
7	0.01734	28.84	32.44

PROBABILITY LAW APPLIED TO FULL DISTRIBUTION

The well-known law of errors states that the probability of an error of observation deviating from the arithmetical mean by the amount $\pm$ x is given by the relation

$$y = \frac{h}{\sqrt{\pi}} e^{-h^2x^2} \tag{7}$$

in which y is the probability, h is a constant known as the modulus of precision, and e is a constant of integration. The equation has the form of curve shown in Fig. 1. When x is 0, $y = \frac{h}{\sqrt{\pi}}$, which is the maximum ordinate of the curve. As can also be seen from the equation, the smaller the value of h is, the greater is the probability of a large error.

Since probability is merely a ratio or percentage, we can apply the theory of errors to the distribution of fuel in the charge of a single cylinder. Equation 7 then represents the probability that the concentration of fuel in an element of volume of the charge selected at random will deviate by the amount $\pm x$ from the arithmetical mean as calculated from the quantities of air and fuel delivered by the carbureter. In this case h can be called the "modulus of homogeneity" and is taken to be directly proportional to the percentage of fuel vaporized in the induction system. The greater the value of h is, the greater is the probability of unit charge selected at random containing the arithmetical mean concentration of fuel. The smaller the value of h is, the greater will be the deviations from the mean concentration.

The maximum value of h obtains when all the fuel is completely vaporized in the induction system. Taking the maximum value of h as 1.0, Table 2 shows the values of the maximum ordinates of the distribution curves corresponding to different values of h.

TABLE 2—MAXIMUM ORDINATES OF DISTRIBUTION CURVES

Value of h	Maximum Ordinate (from $\frac{h}{\sqrt{\pi}}$), Per Cent of Total Volume of Charge
1.00	0.56
0.75	0.42
0.50	0.28
0.25	0.14

Instead of probability, equation 7 can represent the actual per cent of the total volume of the charge in which the concentration of the fuel is greater or less than the calculated arithmetical mean by the amount $\pm x$. We can then plot air-fuel ratio against per cent of total volume of charge and obtain curves which give an idea of how the distribution of fuel in a single charge is governed.

The distribution curves shown in Fig. 2 are plotted from a table of values of the probability integral

$$\frac{2}{\sqrt{\pi}} \int_0^{hx} e^{-h^2x^2} d\,(hx) \tag{8}$$

taking variations from the arithmetical mean air-fuel ratio in intervals of 0.1 and the different values of h as given in Table 1. A study of the distribution curves will show that the area included between each two of the curves and the R-axis is equal to 1 when the ordinate is plotted as per cent of total volume. Curve A shows that a perfectly homogeneous charge is not formed when all the fuel is vaporized in the induction system (maximum value of h). This curve represents the distribution when the mixture is perfectly "dry." Curves B, C and D show the distribution for various degrees of "wetness."

Let us take first the condition in which the fuel is completely vaporized and the carbureter is adjusted to give an air-fuel ratio of 15 to 1. We should then have complete combustion of the fuel, the only products of combustion being CO_2 and H_2O. If the charge is absolutely homogeneous there should be no CO, H_2 or free O_2 in the exhaust from a single cylinder. Suppose that the central ordinate of the distribution curves is erected at the air-fuel ratio 15, it can be seen that in only 0.56 per cent of the total volume of the charge is the air-fuel ratio found to be the same as that delivered by the carbureter, even under the most favorable conditions. About half the charge contains an excess of fuel and the other half an excess of air. Since the exhaust will contain combustion products from all parts of the charge, an analysis will reveal the presence of CO, H_2 and free O_2 in addition to CO_2, the H_2O condensing out. The CO and H_2 are produced in that portion of the charge containing fuel in

excess, while the O_2 is the residue from that portion containing air in excess.

Development of General Formulas

Since the total volume of combustion products for the air-fuel ratio 15 is known from Table 1, the problem is to determine what proportion of combustion products is produced in that portion of the charge containing fuel in excess. The difference between the total volume and the volume so determined will then give the volume of combustion products produced in that portion of the charge containing air in excess. Or, as an additional check, the volume produced in that portion containing air in excess can be calculated by probability, and the sum of the two calculated volumes should then be equal to the total volume for the air-fuel ratio 15.

The first step is to divide the 100 volumes of the charge into two equal portions of 50 volumes. To find what volume of combustion products would be produced in 50 volumes of an absolutely homogeneous charge in which the air-fuel ratio is 15, simply divide relations (1), (2), (4), and (5) by 2 or take one-half of the corresponding tabulated volumes in Table 1. For the carbon gases the volume of combustion products for half the charge is $101/R$, and for the hydrogen gases it is $113.6/R$.

The first calculation will be that of the volume of carbon gases produced in that portion of the charge in which the fuel is in excess. Since the distribution curves in Fig. 2 show the percentage of the total volume of the charge in which the air-fuel ratio has a particular value, it is necessary to multiply the probability expression, or the percentage of total volume, by the volume of combustion products which would be produced by that particular ratio homogeneously distributed in a charge of 50 volumes to determine what volume of combustion products is contributed to the total by that particular element of volume.

If similar products are taken for all the volume elements of the charge containing fuel in different concentrations, the sum of a very large number of such products will then give the total volume of combustion products produced in that portion of the charge in which the fuel is in excess. Or, if y is the probability, and V the volume of combustion products for 50 volumes of charge in which the ratio has a particular value, the total volume of combustion products is given by the sum

$$n \to \infty \frac{\Sigma\ (y_1 V_1 + y_2 V_2 + y_3 V_3 + \ldots\ldots y_n V_n)}{n \to \infty \Sigma\ (y_1 + y_2 + y_3 + \ldots\ldots y_n)} \qquad (9)$$

This is equivalent to taking a weighted mean for a very large number of observations in which the frequencies are represented by y_1, y_2, y_3, etc. To evaluate this expression, it is necessary to express y and V in terms of the same variable. Since the probability function is expressed in terms of deviations $\pm x$ from the mean, the air-fuel ratio in any particular volume element can also be expressed in terms of deviations $\pm x$ from the mean air-fuel ratio. For the carbon gases, then, the volume of combustion products produced in 50 volumes of a homogeneous charge in which the air-fuel ratio is $R - x$ or $R + x$ is given by $101/(R - x)$ or $101/(R + x)$.

Now the fraction of the total charge in which the deviations from the mean air-fuel ratio lie between x and $x + dx$ is represented by

$$y = \frac{h}{\sqrt{\pi}} e - {}^{h^2x^2}\, dx \qquad (10)$$

The volume of combustion products produced in that very small fraction of the charge is

$$yV = \frac{101}{R - x} \times \frac{h}{\sqrt{\pi}}\, e - {}^{h^2x^2}\, dx \qquad (11)$$

and

$$\frac{101}{R + x} \times \frac{h}{\sqrt{\pi}} e - {}^{h^2x^2}\, dx \qquad (12)$$

Taking first that portion of the charge in which fuel is in excess, the total volume of combustion products is given by the sum of a large number of terms similar to (11) divided by the sum of a large number of terms similar to (10).

The final expression to be evaluated is

$$V = \frac{101 \dfrac{h}{\sqrt{\pi}} \displaystyle\int_0^x \frac{e - {}^{h^2x^2}}{R - x}\, dx}{\dfrac{h}{\sqrt{\pi}} \displaystyle\int_0^x e - {}^{h^2x^2}\, dx} \qquad (13)$$

Here x represents the deviation from the mean air-fuel ratio, and the upper limit of the integral is the maximum value of x, which is the point at which the distribution curves intersect the R axis, as shown in Fig. 2.

Calculations of Combustion Products

Now the denominator of this expression can be exactly evaluated, and it has the value 0.5, since it is nothing more than the probability integral. However, since the numerator cannot easily be evaluated with anything like the same degree of exactness, a procedure which will give more exact results is to remove $\frac{h}{\sqrt{\pi}}$ from both numerator and denominator and obtain an approximate solution for both numerator and denominator. If the error introduced is about the same for both numerator and denominator, the final result is much more exact than if we had evaluated the denominator exactly and the numerator only approximately. Since the function $e - {}^{h^2x^2}$ occurs in both integrals, the desired result can be obtained by substituting an approximate value for the function. Now the function $e - {}^{h^2x^2}$ can be expressed as a power series, one form of the expansion being

$$e - {}^{h^2x^2} = 1 - h^2x^2 + \frac{h^4x^4}{2} \qquad (14)$$

If we now substitute for the function only the first term of this expansion, the approximation will admittedly be only a very rough one. But, since the degree of accuracy is about the same for both numerator and denominator, the final result is quite accurate, particularly for small values of x.

After making this substitution, the expression reduces to

$$V = \frac{101 \displaystyle\int_0^x \frac{dx}{R - x}}{\displaystyle\int_0^x dx} \qquad (15)$$

The solution is $\frac{101}{x}\ ln\ \frac{R}{R - x}$, where ln represents the natural logarithm. After converting to common logarithms, the final relation is $\frac{232}{x} \log \frac{R}{R - x}$ (16)

By means of (16) we can calculate the volume of the carbon gases in that half of the charge containing fuel in excess, when the distribution of the fuel is assumed to follow the same law as the distribution of errors of observation, and the maximum value of x is known from the graph of the distribution as shown in Fig. 2. Since the maximum value of x varies inversely as the modulus of homogeneity h, a convenient approximate value for x in terms of h is given by $\frac{\sqrt{\pi}}{h}$, which can be substituted for x in the relation (16).

For any degree of homogeneity, then, the volume of the carbon gases after combustion in that portion of the charge containing fuel in excess is calculated from

$$V_1 = 131\, h \log \frac{Rh}{Rh - 1.77} \qquad (17)$$

By a similar process the volume of the carbon gases in that half of the charge containing air in excess is found to be

$$V_2 = 131\, h \log \frac{Rh + 1.77}{R} \qquad (18)$$

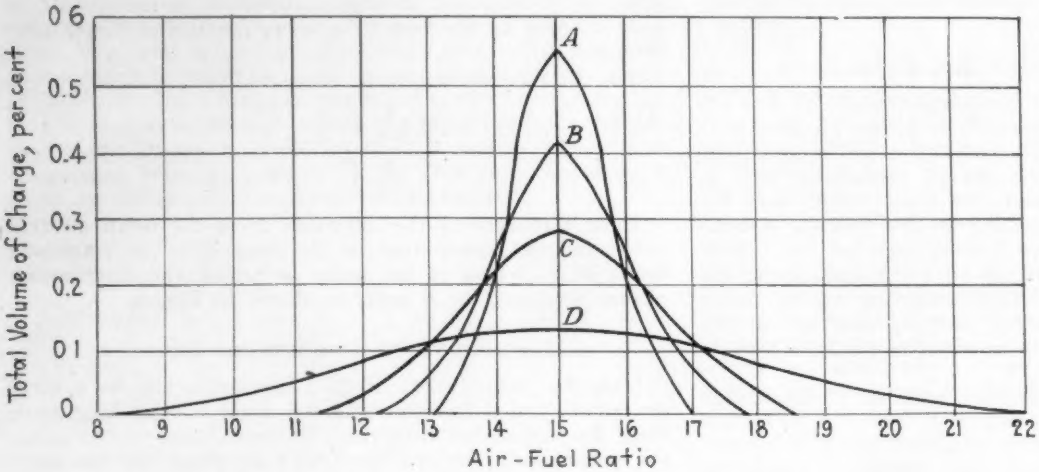


FIG. 2—DISTRIBUTION OF FUEL IN THE CHARGE

The Carbureter Is Set to Give a Particular Mixture Ratio, and the Modulus of Homogeneity Is Varied. The Curves Are Plotted by Taking Different Values for hx in the Probability Integral. Curve A Represents the Distribution When All the Fuel Is Vaporized in the Induction System, B, 75, C, 50, and D, 25 Per Cent Vaporized

The sum of (17) and (18) should be equal to $202/R$, which, for the ratio 15, is 13.46 volumes of carbon gases.

Similar expressions, which differ only in the value of the constant coefficient, can be obtained for the volumes of the hydrogen gases in the two halves of the charge. It is not necessary to do so, however, since the volume of the hydrogen gases can be calculated by means of relation (3) when the volume of the carbon gases is known.

Some idea of the application of the relations derived above can be obtained from the figures in Table 3. We are assuming that the carbureter delivers a mixture in which the air-fuel ratio is 15, and the volumes are calculated by taking different values for h, the modulus of homogeneity.

It can be seen that the figures in the last column do not differ appreciably from 13.46 when the value of h is large, and the maximum error is only 8 per cent for the lowest value of h taken. The error here is due to the approximate solution of the integrals in (13). Fortunately, we know what the sum of the two calculated volumes should be and can correct the calculated values before making further use of them for the estimation of the volume of the hydrogen gases in the two halves and the volume of the residual oxygen.

TABLE 3—VOLUME OF CARBON GASES AFTER COMBUSTION IN VARIOUS PORTIONS OF CHARGE

Carburetor ratio = 15; volume of carbon gases = $202/R$ = 13.46

Values of h	$131\, h \log \frac{Rh}{Rh - 1.77}$	$131\, h \log \frac{Rh - 1.77}{Rh}$	Sum
1.0	7.05	6.35	13.40
0.75	7.31	6.22	13.53
0.50	7.66	6.03	13.69
0.25	9.05	5.49	14.54

In correcting the volumes in Table 3, the percentage error in the sum is deducted from the individual volumes, and the final sum is then 13.46 in each case. These corrected values are then multiplied by 1.125 to obtain the volumes of the hydrogen gases. Since one-half the charge contains air in excess, the volume of O_2 remaining is calculated from the relation

$$10.45 - (vCO_2 + vH_2O/2) \qquad (19)$$

Finally, the total volume after combustion is evidently the sum of 79.1 volumes of N_2, the total volume of combustion products, and the volume of the residual O_2.

In Table 4 are shown the corrected volumes for the ratio 15, assuming different values of h.

If the charge were absolutely homogeneous the total volume after combustion for the ratio 15 would be 107.70.

The procedure employed above is not limited to the case in which the carbureter is adjusted to the air-fuel ratio giving complete combustion but can be applied equally well to any assumed carbureter adjustment. If the mean ratio is such that the plus deviations lie partly in the region in which fuel is in excess and partly in the region in which air is in excess, the procedure is exactly the same. However, to estimate the volume of residual oxygen in the region in which air is in excess, it is necessary to decompose the limits in the integral giving the volume of the combustion products for the plus deviations and calculate the volume in each region. The first region embraces those deviations lying between the mean ratio and the point of complete combustion, and the second region contains those deviations lying between the point of complete combustion and the maximum deviation.

TABLE 4—CORRECTED VOLUMES OF COMBUSTION PRODUCTS FOR AIR-FUEL RATIO 15 TO 1

Value of h	Minus Deviations CO_2 CO	Minus Deviations H_2O H_2	Plus Deviations, Volume CO_2	Plus Deviations, Volume H_2O	Residual O_2	Total Volume after Combustion
1.00	7.05	7.93	6.35	7.14	0.57	108.27
0.75	7.27	8.17	6.19	6.96	0.78	108.48
0.50	7.53	8.47	5.93	6.67	1.18	108.88
0.25	8.41	9.46	5.05	5.67	2.62	110.32

When the maximum deviation is greater than the mean air-fuel ratio, the expression used for calculating the volume of combustion products in the region containing minus deviations becomes negative and cannot be evaluated. This difficulty can be avoided by assuming that the distribution curves are skewed as shown in Fig. 3. The symmetrical distribution curve represented by the full line is a sort of ideal limiting condition which never is realized in the cylinder of the engine. On the other hand, the assumption of skew distribution, as shown by the dotted curve, furnishes an explanation for the experimental observation that the exhaust from a single cylinder can contain 4 or 5 per cent of free oxygen, and CO and H_2 corresponding to a very rich mixture. Calculations based on the assumption of skew distribution will be published in a later paper.

In a recent paper, H. L. Callendar[5] indirectly suggests the possibility of non-homogeneous charges being formed on account of the condensation of the fuel into microscopic nuclei during the compression stroke of the engine. Mr. Callendar argues that the low critical pressures and high critical temperatures of the paraffin hydrocarbons cause them to behave in an anomalous manner when compressed adiabatically. He constructs temperature-entropy diagrams which show that the saturated vapors of these hydrocarbons will actually condense into small liquid nuclei when compressed adiabatically. His suggestion has been objected to on the ground that the vapors are not saturated under engine conditions. True, if the charge is perfectly homo-

[5] See *Engineering*, April 16, 1926, p. 510.

geneous the vapor is unsaturated, but certainly the charge may be saturated locally with vapor, or even contain liquid fuel. The suggestion made by Mr. Callendar seems very plausible when the charge is regarded as non-homogeneous, and it can be taken as an argument in favor of skew distribution.

Discussion

The very brief treatment given herein is admittedly idealistic and is only a starting point for a more extended treatment. It is necessary to explain what is meant by non-homogeneous distribution of the fuel. On account of turbulence or disordered mass motion of the charge, it might be expected that any sort of quantitative treatment of fuel distribution is meaningless because the distribution of the fuel would be constantly changing. It is true that the "complexion" if a cross-section of the charge is constantly changing and is never the same at the same instant in any two strokes. In the *a priori* treatment adopted above, we have to assume that at the particular instant in the stroke in which a small element of volume of the charge undergoes combustion the air-fuel ratio in that element of volume is a matter of chance, which, normally, can be calculated by the law of errors. The charge would then burn as though the fuel were actually distributed as assumed. We can then predict the composition of the exhaust.

The methods of a *posteriori* probability would really be much more useful for our purpose. That is, we should be able to calculate from the composition of the exhaust what must have been the air-fuel ratio in each volume element of the charge at the instant of burning in order to produce a mixture of combustion products having the determined composition. This procedure, however, is much more difficult and cannot be pursued with success until a complete *a priori* system is formulated.

There is also an element of chance in the sampling process. Suppose that a sample of 100 cc. (6.102 cu. in.) is drawn from one cylinder of an engine running at 1200 r.p.m., and that the time required for drawing the sample is 1 min. The sample will then contain combustion products from 600 different explosions, no two of which are exactly alike. Also, the sample is taken at one point in a moving stream of exhaust gas. After analysis of the sample, how can any conclusions be drawn about the composition of the charge?

The probability idea can also be extended to the thermodynamics of the engine, but the extension cannot be made until the physical chemistry of the working fluid is thoroughly understood. Probability will no doubt demand that the working fluid have hypothetical properties. However, if performance can be predicted from hypothesis, the hypothetical nature of the assumptions disappears.

A little reflection reveals that internal-combustion-engine theory is really in a very elementary stage. In the past the engine has been regarded almost exclusively as a heat engine. It is, in fact, really a physical-chemical engine, depending for its operation on a very complex chemical reaction. And when it is realized that every feature of mechanical design, from the carbureter jet to the rear end of the muffler, has some effect on the combustion process going on in the cylinder, the incompleteness of the present state of our knowledge is obvious.—Clarke C. Minter.

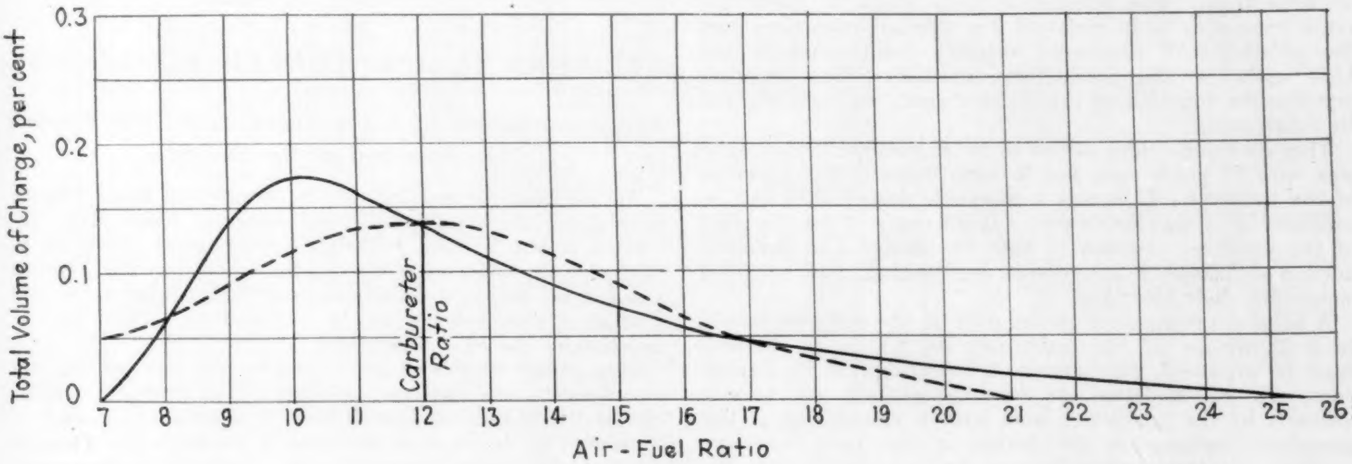


Fig. 3—Ideal and Probable Distribution Curves

Ideal Symmetrical Distribution, a Limiting Condition Never Realized in the Cylinder of an Engine, Is Represented by the Full-Line Curve; the Dotted Curve Is a Skewed or Non-Symmetrical Distribution Curve Which Furnishes an Explanation for Certain Experimental Observations

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The Human Factor in Trade

LABOR is less effective all around in Germany than in the United States; and it would seem that Germany's people have but to move to the better region in order to enjoy its better conditions. So it would be if the cause of advantage in the United States were merely of a physical sort—climate, land, or what not—and if the Germans were quite as capable of utilizing the natural conditions as the Americans. But if the differences in effectiveness do not rest purely on physical grounds; if they are due to aptitudes which the Americans possess but the Germans do not; if the Germans on moving to the United States could not there apply their labor with the same intelligence, ingenuity, vigor, as the Americans, there would be no certainty of gain from the shift. As we shall see, causes of this kind do operate. Not physical causes alone, natural resources and the like, determine the current of international trade; the human factor counts heavily.—F. W. Taussig, in *International Trade*.

Production Engineering

DESIGNING FOR PRODUCTION

Manufacture Aided by Cooperation Between Design and Production Engineers

"Can you make this, Bill?" and the chief turns over the sketch of a new unit assembly having a housing that is weird and fanciful. Bill looks it over carefully and decides that it can be made; in fact, figures how he would go about making it. Then comes the next question, "How much will it cost?"

That opens the real part of the discussion, but surprisingly little is said at this stage about the dollars and cents involved; it is more a matter of operations and methods. The designer knows what he is after in final form and the producing genius knows how he can get it. Usually the production man tries to combine and modify operations, for he knows primarily what type of operations are more expensive than others and what equipment he has available for the work.

Lugs are changed to permit a through-milling operation, with a set-up of three or four or a dozen pieces at once, and the shape is changed to avoid open gaps, where the tools would be "cutting air." Facings are altered to shorten the tool traverse. Awkward shoulders and fillets are discussed to determine whether they can be modified to advantage. The production man keeps in mind the more expensive tools required for special operations and the possibility of breakage; avoiding trouble-makers and high costs in the production schedule. The designer watches the function of the finished part, its strength and its lubrication.

This conference idea seems to be as common today as it was rare 10 years ago, and it contributes to the progress of the industry. It means a workable design that can be produced at a reasonable cost. It uncovers at least a part of the problems common to both the design and the production divisions of automotive engineering, and provides means for their solution.

A helpful preparation on the part of the designer would be a knowledge of the machinery on which his designs must be produced, particularly a knowledge of its limitations. He will find that the resulting attitude will be met cordially by the production man with a recognition of the important features in the design of the part that are essential for the performance of its function in the finished unit.

Why Cooperation Is Vital

This attitude of cooperation is even more vital under the conditions now existing than ever before. Refinement in design to make a finer car, and refinement in production to make it at lower cost, are the present trends of automotive manufacture. And further, for the builder whose volume of market demand does not permit him to enjoy the greater economies of mass production available to other cars in his class, there must be included in his product an intrinsic value that will justify its price. Cooperation is most necessary to this end.

Designing for production, then, is quite as important as designing for style or for mechanical function, especially in the medium-price ranges, because of the importance of economy in manufacture. While the equipment installed and the methods in vogue in the factory generally constitute the means by which the part must be produced, reasonable consideration should be given, even by the designing department, to other models of machinery on the market. Added features of design available with new mechanical equipment may be important enough to justify its purchase.

The industry has learned not to specialize too highly in single-purpose equipment except where sufficient mass production is assured to justify the expense. In the intermediate-production ranges, automatic machinery is desirable and should be considered first, unless the job itself makes this prohibitive. Flexibility or a fairly wide range of adaptability is generally the most important single consideration in the equipment for medium-production ranges.

The various models and types of manufacturing equipment offered for the same purpose present no small problem in the choice of equipment for specific manufacturing conditions, because they possess widely different possibilities in adaptability and refinement of operation as well as in quality and quantity of production. Features of equipment that will aid in accomplishing what is wanted in design and the adaptability of the one model to the exact production requirements as to both quantity and quality present other problems upon which the designer and producer may meet for a solution. Is there any doubt, then, that whole-hearted cooperation will aid materially toward successful manufacturing under present conditions, or that success without it will be difficult for any manufacturer?—E. P. Blanchard, Bullard Machine Tool Co.

CYLINDRICAL AND THREAD PLUG-GAGES

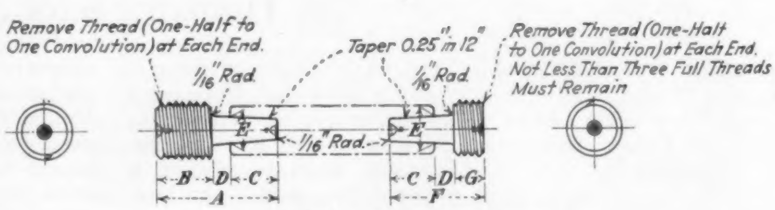
Recommendations of Independent Committee Offered for Approval of the Society

At the Dec. 5 meeting of the American Gage Design Committee, the organization and work of which were described briefly in The Journal for December, 1927, on p. 639, recommendations were decided upon for the handles and gaging plugs of cylindrical and thread plug-gages for a range of sizes from ¼ to 1½ in., inclusive. These recommendations are shown herewith.

This report has been submitted to the Society for its consideration and has been referred to the Production Division of the Standards Committee. Publication of it in this issue of The Journal is intended to acquaint the automotive industry more generally with what has been accomplished and to secure from it an expression as to acceptability of the recommendation as a general standard.

It is requested that the members, particularly production engineers and executives who have opinions on their own acceptance of the report as given, will send their approval or criticism to the Standards Department of the Society. Such opinions will be referred to the Production Division of the Standards Committee for consideration in formulating recommendations that it may make to the Society.

Recommendations for ring-gage standards for the same



Thread Plug-Gages
(See table on p. 25)

THREAD PLUG DIMENSIONS

(See cut on p. 24)

Size		Diameters: Go Pitch	Go Minor	Go Major	Not Go Class 2 Pitch	Not Go Class 2 Minor	Not Go Class 2 Major	Not Go Class 3 Pitch	Not Go Class 3 Minor	Not Go Class 3 Major	General Dimensions: Size Handle	Go A	Go B	Both C	Both D	Both E	Not Go F	Not Go G
1/4—20	Minimum Maximum	0.2175 0.2177	0.1850	0.2500 0.2505	0.2211 0.2213	0.1886	0.2403 0.2408	0.2201 0.2203	0.1876	0.2403 0.2408	1	1 1/2	1/2	3/4	1/4	0.239 0.240	1 5/16	5/16
1/4—28	Minimum Maximum	0.2268 0.2270	0.2036	0.2500 0.2505	0.2299 0.2301	0.2067	0.2431 0.2436	0.2290 0.2292	0.2058	0.2431 0.2436								
5/16—18	Minimum Maximum	0.2764 0.2766	0.2403	0.3125 0.3130	0.2805 0.2807	0.2444	0.3017 0.3022	0.2794 0.2796	0.2433	0.3017 0.3022								
5/16—24	Minimum Maximum	0.2854 0.2856	0.2583	0.3125 0.3130	0.2887 0.2889	0.2616	0.3044 0.3049	0.2878 0.2880	0.2607	0.3044 0.3049								
3/8—16	Minimum Maximum	0.3344 0.3346	0.2938	0.3750 0.3756	0.3389 0.3391	0.2983	0.3629 0.3635	0.3376 0.3378	0.2970	0.3626 0.3635	2	1 3/4	3/4	3/4	1/4	0.309 0.310	1 3/8	3/8
3/8—24	Minimum Maximum	0.3479 0.3481	0.3208	0.3750 0.3755	0.3512 0.3514	0.3241	0.3669 0.3674	0.3503 0.3505	0.3232	0.3669 0.3674								
7/16—14	Minimum Maximum	0.3911 0.3913	0.3447	0.4375 0.4381	0.3960 0.3962	0.3496	0.4236 0.4242	0.3947 0.3949	0.3483	0.4236 0.4242								
7/16—20	Minimum Maximum	0.4050 0.4052	0.3725	0.4375 0.4380	0.4086 0.4088	0.3761	0.4278 0.4283	0.4076 0.4078	0.3751	0.4278 0.4283								
1/2—13	Minimum Maximum	0.4500 0.4502	0.4000	0.5000 0.5006	0.4552 0.4554	0.4052	0.4851 0.4857	0.4537 0.4539	0.4037	0.4851 0.4857								
1/2—20	Minimum Maximum	0.4675 0.4677	0.4350	0.5000 0.5005	0.4711 0.4713	0.4386	0.4903 0.4908	0.4701 0.4703	0.4376	0.4903 0.4908								
9/16—12	Minimum Maximum	0.5084 0.5086	0.4542	0.5625 0.5631	0.5140 0.5142	0.4598	0.5463 0.5469	0.5124 0.5126	0.4582	0.5463 0.5469	3	1 7/8	7/8	3/4	1/4	0.408 0.410	1 1/2	1/2
9/16—18	Minimum Maximum	0.5264 0.5266	0.4903	0.5625 0.5630	0.5305 0.5307	0.4944	0.5517 0.5522	0.5294 0.5296	0.4933	0.5517 0.5522								
5/8—11	Minimum Maximum	0.5660 0.5663	0.5069	0.6250 0.6256	0.5719 0.5722	0.5128	0.6073 0.6079	0.5702 0.5705	0.5111	0.6073 0.6079								
5/8—18	Minimum Maximum	0.5889 0.5892	0.5528	0.6250 0.6255	0.5930 0.5933	0.5569	0.6142 0.6147	0.5919 0.5922	0.5558	0.6142 0.6147								
3/4—10	Minimum Maximum	0.6850 0.6853	0.6200	0.7500 0.7506	0.6914 0.6917	0.6264	0.7306 0.7312	0.6895 0.6898	0.6245	0.7306 0.7312								
3/4—16	Minimum Maximum	0.7094 0.7097	0.6688	0.7500 0.7506	0.7139 0.7142	0.6733	0.7379 0.7385	0.7126 0.7129	0.6720	0.7379 0.7385								
7/8— 9	Minimum Maximum	0.8028 0.8031	0.7306	0.8750 0.8757	0.8098 0.8101	0.7376	0.8534 0.8541	0.8077 0.8080	0.7355	0.8534 0.8541	4	2 3/16	1	7/8	5/16	0.608 0.610	1 13/16	5/8
7/8—14	Minimum Maximum	0.8286 0.8289	0.7822	0.8750 0.8756	0.8335 0.8338	0.7871	0.8611 0.8617	0.8322 0.8325	0.7858	0.8611 0.8617								
7/8—18	Minimum Maximum	0.8389 0.8392	0.8028	0.8750 0.8755	0.8430 0.8433	0.8069	0.8642 0.8647	0.8419 0.8422	0.8058	0.8642 0.8647								
1 — 8	Minimum Maximum	0.9188 0.9191	0.8376	1.0000 1.0007	0.9264 0.9267	0.8452	0.9757 0.9764	0.9242 0.9245	0.8430	0.9757 0.9764								
1 —14	Minimum Maximum	0.9536 0.9539	0.9072	1.0000 1.0006	0.9585 0.9588	0.9121	0.9861 0.9867	0.9572 0.9575	0.9108	0.9861 0.9867								
1 1/8— 7	Minimum Maximum	1.0322 1.0325	0.9394	1.1250 1.1257	1.0407 1.0410	0.9479	1.0972 1.0979	1.0381 1.0384	0.9453	1.0972 1.0979								
1 1/8—12	Minimum Maximum	1.0709 1.0712	1.0167	1.1250 1.1256	1.0765 1.0768	1.0223	1.1088 1.1094	1.0749 1.0752	1.0207	1.1088 1.1094								
1 1/4— 7	Minimum Maximum	1.1572 1.1575	1.0644	1.2500 1.2507	1.1657 1.1660	1.0729	1.2222 1.2229	1.1631 1.1634	1.0703	1.2222 1.2229	5	2 5/8	1 1/4	1	3/8	0.808 0.810	2 1/8	3/4
1 1/4—12	Minimum Maximum	1.1959 1.1962	1.1417	1.2500 1.2506	1.2015 1.2018	1.1473	1.2338 1.2344	1.1999 1.2002	1.1457	1.2338 1.2344		2 3/8	1					
1 1/2— 6	Minimum Maximum	1.3917 1.3920	1.2834	1.5000 1.5008	1.4018 1.4021	1.2935	1.4676 1.4684	1.3988 1.3991	1.2905	1.4676 1.4684		2 7/8	1 1/2					
1 1/2—12	Minimum Maximum	1.4459 1.4462	1.3917	1.5000 1.5006	1.4515 1.4518	1.3973	1.4838 1.4844	1.4499 1.4502	1.3957	1.4838 1.4844		2 5/8	1					

GENERAL SPECIFICATIONS FOR THREAD PLUGS

PITCH DIAMETERS

Minimum, All Sizes; Go—Basic; Not Go—Basic plus National Screw Thread Commission Tolerance.

Maximum, ¼ to 9/16 Diameter; Go—Minimum +0.0002; Not Go—Minimum +0.0002.

⅝ to 1½ Diameter; Go—Minimum +0.0003; Not Go—Minimum +0.0003.

MAJOR DIAMETERS

Minimum All Sizes; Go—Basic; Not Go—Basic—15% Double Thread Depth.

Maximum 6 Threads; Go—Basic +0.0008; Not Go—Minimum +0.0008.

7-9 Threads; Go—Basic +0.0007; Not Go—Minimum +0.0007.

10-16 Threads; Go—Basic +0.0006; Not Go—Minimum +0.0006.

18-28 Threads; Go—Basic +0.0005; Not Go—Minimum +0.0005.

MINOR DIAMETERS

American Standard Form or Sharper.

CENTERS

Female.

DUST GROOVE

Go—Manufacturers' Practice.

MARKING

Go—¼-Basic Pitch Diameter on Shank End; Not Go—Minimum Pitch Diameter on Shank End.

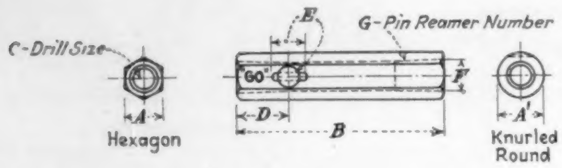
Go—5/16-1½ Inclusive—Size, Thread and Basic Pitch Diameter on Thread End; Not Go—Size, Thread and Minimum Pitch Diameter on Thread End.

THREAD ANGLE

Tolerance in Half Angle ±10 min.
Tolerance in Full Angle 15 min.

LEAD ERROR

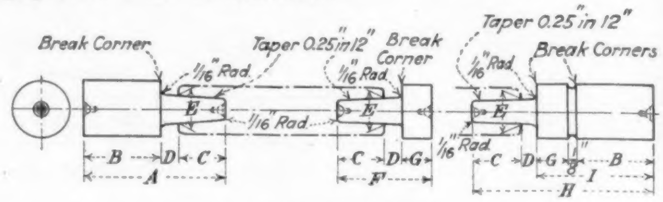
±0.0002 between any two threads, non-accumulative, not farther apart than one diameter.



HANDLES

Size	Dimensions							
	A	*B*	*C*	*D*	*E*	*F*	*G*	*A'*
1	3/8	2 3/4	7/32	25/32	1/8x1/2	0.239 0.240	4	7/16
2	1/2	3	L 0.290	25/32	15/64	0.309 0.310	6	5/8
3	11/16	3 1/4	25/64	27/32	11/32	0.409 0.410	7	13/16
4	7/8	3 5/8	37/64	63/64	3/8	0.609 0.610	10	1 1/16
5	1 1/8	4	25/32	1 1/8	7/16	0.809 0.810	11	1 5/16

range of sizes are progressing sufficiently so that they probably will be submitted by the committee within 3 months, and both larger and smaller plug-gages and ring-gages are under consideration.



CYLINDRICAL PLUGS

Size Handle	Range		Go		All			Not Go		Progressive	
	Above	Including	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*
1	0.240	0.365	1 3/4	3/4	3/4	1/4	0.239 0.240	1 5/16	5/16	2 3/16	1 3/16
2	0.365	0.510	2	1	3/4	1/4	0.309 0.310	1 3/8	3/8	2 1/2	1 1/2
3	0.510	0.825	2 1/4	1 1/4	3/4	1/4	0.408 0.410	1 1/2	1/2	2 7/8	1 7/8
4	0.825	1.135	2 9/16	1 3/8	7/8	5/16	0.608 0.610	1 13/16	5/8	3 5/16	2 1/8
5	1.135	1.510	2 7/8	1 1/2	1	3/8	0.808 0.810	2 1/8	3/4	3 3/4	2 3/8

Overproduction

THE losses resulting from overproduction are enormous, but they are the price we pay for the maintenance of freedom. For, obviously, freedom cannot mean either that capital shall receive a return or that labor shall be paid a living and saving wage for rendering services which are already being rendered in abundance.

Moreover, the pressure of overproduction is the great stimulus to efficiency. In the production of every commodity there is to be found every degree of efficiency, from the least to the greatest. When the supply is less than the demand, the least efficient producer is kept alive by a high price, and the most efficient profits so much as to put pressure upon increased production.

This procedure naturally ends in overproduction and a price so low that the least efficient producer ceases to exist and the most efficient devotes his energies to increased efficiency to recoup his lessened profits. Increase in population and higher standards of living in the course of time bring about a demand in excess of production once more, and the same cycle is repeated.

The wide fluctuations which formerly came from this process have been greatly lessened in this Country by the policies of big business, which is interested, first, in stability, and avoids taking advantage of a short supply to secure an excess profit, a procedure which would simply bring increased competition into existence, and, in the last analysis, cost more than it would earn.

It would be easy to prevent overproduction in many lines of business if public policy permitted producers to combine to limit production. However, it is at least as important to protect consumers from extortion as it is to protect producers from the results of overproduction. Our Government has, therefore, by both the State and National anti-trust laws, insisted that no agreements between producers shall be made which so limit supply as to make possible the extortion of an unfair value from the consumer. It is difficult to draw the line between legitimate activities designed to prevent overproduction and those agreements which destroy equality of opportunity and aim at an unfair enhancement of price.

Overproduction, due to ignorance and uncoordinated planning, is to be avoided, and supply is to be adjusted to demand. Production, however, is not to be curtailed by agreement with a view to exacting an unfair price. Farther than this we can hardly go in protecting either agriculture or industry from the risk of overproduction.—Robert S. Brookings, president of the Institute of Economics, in a memorandum to the President.

Operation and Maintenance

The report of the West Coast Subcommittee on Operation and Maintenance was presented at the Transportation Meeting session held in Chicago on Tuesday afternoon, Oct. 25, by E. C. Wood,[1] chairman of the subcommittee, and is herewith printed in full. It follows the publication in the December issue of THE JOURNAL of the reports of the main Operation and Maintenance Committee, and the subcommittee reports on Nomenclature, Cost Accounting, and State Regulations. As stated in the December issue, the other reports, additional data, and the discussion at the Operation and Maintenance Committee session are being reserved for subsequent publication, as the limitations of available space prevent publication of all the information in a single issue.

Pacific-Coast Fleet-Maintenance Practice

The increased recognition that is now being accorded to the fleet operator and the automotive engineer is certainly gratifying to the fleet operators in the States of California, Oregon, Nevada and Washington. There is no question that this cooperation and coordination will be the basis for maximum efficiency. The fleet operators realize that a considerable amount of work is necessary if transportation is to be put on an economical basis, and the data and information accumulated for better servicing and maintenance will require a clearing-house for determining possible changes in design and solving the problem of inaccessibility of parts and of mechanical failures. I feel that the Operation and Maintenance Committee of the Society is the proper channel for analyzing this information, and that the Society's Research Department can be a very important factor in helping to solve maintenance and operation problems.

The data presented herein result from questionnaires sent to fleet operators in the four States named. I received remarkable cooperation from some fleet operators and none from others; but, as a whole, they were entirely in sympathy with the proposed work. I found that all fleet operators have different systems or set-ups which control repair schedules, dispatching systems and service controls. They felt that service controls are necessary from many viewpoints. Some operators find it necessary to keep a check on equipment as it goes through the shops, as to length of time and the like. The record is kept on a blackboard in some cases, or on a visible board utilized for servicing equipment, or in book form. One large-scale operator in Oakland, Cal., finds it necessary to have a dispatching system like that of a railroad, which controls the movements of 250 vehicles.

From questionnaires returned that report the percentage of repairs of component parts, the following figures are of interest. The percentages were compiled on the basis of age of equipment, idle time in the repair-shop, number of man-hours expended in labor, material, replacement parts, cost of auxiliary equipment, and interest on the additional investment.

	Per Cent
Repairs to Engine	36.23
Rear Axle	13.62
Bodies	11.04
Transmission	7.36
Clutch	5.52
Radiator	5.15
Front Axle	4.51
Ignition	4.42
Frames	3.13

[1] M.S.A.E.—Superintendent of transportation, Pacific Gas & Electric Co., San Francisco.

CLASS-A EQUIPMENT

The age of the five cars in this experimental class ranged from 1 to 5 years. The average time spent in making adjustments before parts were changed averaged 800 man-hours per year. With the cost data available, the object was to standardize a maintenance and operating cost for this class of vehicle in this section. The cars having regular factory equipment were then placed on the dynamometer rack and the data were recorded. The reconditioning done included:

- Changing the ignition unit
- Changing and making interchangeable the transmission bands and lining
- Reconditioning the brakes and brake-linings
- Installing a system of lubrication, such as the Critz, the Dot, the Alemite, or the Zerk
- Installing a governor
- Reinforcing the engine hangers
- Sealing the crankcase gasket with a sealing medium and making other minor changes, such as adjusting the valve seats to 1/16 in. and the like

The result gave an increase of 20 per cent in operating efficiency and a decrease of 30 per cent in maintenance costs.

CLASS-B EQUIPMENT

Some of the factory equipment that had to be reconditioned on the Class-B units included:

- Alloy pistons having too large a tolerance or in which the material was unsuitable to give an economical maintenance and operating cost
- Valve guides not in alignment, due to wrong production and jig-setting methods and poor inspection
- Valve-stem clearances in valve guides in which the limits were not close enough, both tolerances being negative
- Clutch facings of unsatisfactory composition that will hold up for only 1500 to 2000 miles
- Transmission gears that were soft and had not sufficient hard-steel tooth-surface
- Bearings in the front of the transmission in which the load capacity of this bearing was too small, a larger bearing being required
- Rear bearings in the transmission in which the bearings were not square with the cage and the tolerance and alignment were not sufficiently accurate
- Propeller-shaft pinion-bearing cones that were flat or did not fit accurately
- Rear-brake support-brackets that snapped at the plate

Axle shafts that broke at the end of the squared section

Differential compensating gears and axle gears that allowed too much play, permitting a backlash of as high as one-quarter turn before motion was transferred to the rear wheels

Spot welding on the body that broke down

Paint on the wheels which scaled off within a short period.

As these are the major defects and their causes can be traced to the cost of production, it is evident that if the fleet operator wishes to continue to operate vehicles he will need to reconstruct the unit before an economical maintenance cost can be established. On the other hand, if the manufacturers are going to have the public pay for the experiments and feel that it is necessary only to have their vehicles pass the 30-day-guarantee period, I think it is time that a mechanical evaluation of units be listed each year or each certain period to give the layman at least some knowledge of what he is purchasing. If the fatigue-of-metals factor and the factor of safety of the vehicles 2 years old or more that are on the road today were known, how many would feel safe to ride in them at a speed of 40 m.p.h.?

Light Commercial-Equipment, Class C

In this class of equipment we are again confronted with the fact that the maintenance cost is high in proportion to the amount of work done and the cost of operation. The maintenance cost in this class of unit has been reduced 15 per cent by various mechanical changes. To make an analysis of each job would in itself fill a volume. But in many cases the engineering department has had to cheapen the design and the efficiency department has increased the tolerances and lowered the inspection requirements to reduce the cost of production. This condition does not predominate in the higher priced and heavier equipment due to the fact that the factors of safety must be higher and the units are stripped down to chassis and powerplant. When we consider buying a unit on the basis of horsepower, we find that the margin of cost in proportion to the quality of the product is in a different cycle than in the lighter units.

Provisions of State Laws

More uniform laws are a necessity for both the individual owner and the fleet operator. It is safe to say that no vehicle can pass through three States without special equipment unless the driver has special authorization or permits of some nature. In some instances laws are worded and enforced so that two State licenses must be paid for a truck if it operates either side of the State line at semi-monthly intervals. Laws governing signals, lamps, tires, weights, speeds, dimensions, and many other items are in effect that prevent the fleet operator from transferring his vehicles from one location to another without large expenditures in accessories and changes in construction to meet the required conditions.

State regulations governing the operation of trucks on the highways in several Western states are presented herewith. Some of the laws, either new or holdover, which regulate the commercial and private freight-haulers in New Mexico, Oregon, Texas, Utah and Washington, are:

New Mexico

Gasoline tax, 5 cents per gal. All municipalities have power to prescribe the qualifications of drivers.

Speed limits for trucks, with carrying capacity under 5000 lb., 25 m.p.h.; over 5000 and under 8000 lb., 20 m.p.h.; over 8000 and under 10,000 lb., 18 m.p.h.; and 10,000 lb. or over, 15 m.p.h. In passing schools and operating in territory where houses are less than 500 ft. apart, 10 m.p.h. All trucks must be equipped with rear-vision mirrors. Drivers must render assistance in case of accident.

Oregon

Gasoline tax, 3 cents per gal. Six-wheel vehicles are eliminated, as they can bear no greater load than four-wheel vehicles..

When the total tire-width of a vehicle is less than 30 in., the combined weight shall not exceed 500 multiplied by the sum of the tire width of the two wheels of one axle. For tire widths of 30 in. or more, the axle weight in pounds shall not exceed the product of 600 multiplied by the sum of the tire width of the two wheels of such axle. For any two axles spaced less than 8 ft. apart, the combined weight of any one of such axles shall not exceed 8000 lb. Maximum weight, loaded, is 20,000 lb. or, if a truck carries over 30-in. width of rubber, 600 lb. per in. on each axle. This is a new phase of the law which gives the maximum weight of 14,400 lb. on any one axle no matter how many inches width of rubber the equipment carries. The maximum weight formerly allowed a loaded truck on the Oregon highways was 22,000 lb. Speed limits are as follows:

Total Tire Width, In.	Solid Tires, M.P.H.	Pneumatic Tires, M.P.H.
Not over 14	25	..
Over 14, not over 16	20	..
Over 16, not over 22	18	..
Over 22, not over 30	16	25
Over 30	12	20

Texas

Ruth Mims, assistant secretary of the State Highway Commission of Texas, writes:

> Our highway laws are in confusion, but we hope they will be revised and clarified in a complete code at the special session of the legislature this fall.

Utah

H. S. Kerr, chief engineer of the State of Utah, writes:

> The uniform motor-vehicle laws were introduced at the recent session of the legislature, but there was not sufficient time for their consideration and a copy of the motor laws now in force is enclosed.

These laws include: Registration fee for pneumatic-tired trucks of ½-ton capacity or less, $5.00; ¾-ton, $7.50; 1-ton, $10.00; 1½-ton, $15.00; 2-ton, $22.50; 2½-ton, $30.00; 3-ton, $40.00; 3½-ton, $55.00; 4-ton, $70.00; 5-ton, $100.00.

Solid Tires.—For 1-ton capacity or less, $25; 1½-ton, $35; 2-ton, $50; 2½-ton and 3-ton, $75; 3½-ton, $100; 4-ton, $125; 4½-ton, $130; 5-ton, $140.

All pneumatic-tired trailers, 1 to 4 tons capacity, $10 to $50; solid-tired trailers, $15 to $75.

In case of accident, drivers must stop and give aid.

Speed limits are 30 m.p.h. if the gross weight is less than 6000 lb. on pneumatic tires; 20 m.p.h. for solid tires at the same weight; 20 m.p.h. between 3 and 4-tons gross capacity on pneumatics, and 15 m.p.h. for the same weights on solid tires; 16 m.p.h. for over 4 tons on pneumatic tires and 8 m.p.h. for the same weight on solid tires.

Maximum Load.—The total maximum load allowed on any one wheel is 3¼ tons, provided the total maximum weight of the vehicle and load shall not in any event exceed 10 tons. The total load on any one wheel is limited to 600 lb. per in. width of tire on all highways improved with rigid-surface pavements on a concrete base and 400 lb. per in. width of tire on dirt or gravel roads.

Washington

Gasoline tax remains unchanged, 2 cents per gal. No new taxes or fees imposed.

Gross weight for six-wheel trucks, 27,500 lb.; gross weight greater than 18,500 lb. not to be on one axle, and not over 800 lb. per in. width of tire. Where gross weight is 12,000 lb. or more, the wheelbase must be 10 ft. For two-wheel trailers, 12 ft. must intervene; for four-wheel trailers, the distance between the second and the third axles

must be 6 ft. 6 in. and between the third and the fourth axles it must be 12 ft. Vehicles with six axles, properly spaced, may carry the maximum gross load on the highways. For six-wheel vehicles, the distance between the first and the second axles must not be less than 12 ft.; the second and third axles must not be less than 3 ft. 6 in. apart. For trailers, the same regulations apply as for four-wheel trucks. Steel-cable and drawbar connections are required. The over-all maximum width is 8 ft.

The maximum weight allowed on metal tires is 10,000 lb. Solid tires must have a good elastic cushion of 1½ in. when the load per wheel is over 6000 lb.

Rear-vision mirrors are required where the view to the rear is obstructed by the cab.

Windshields must be equipped with an automatic wiper.

Head-lamp lenses must meet eight-point requirements; they must be inspected and adjusted. After Dec. 31, 1927, none but approved lenses or reflectors may be used.

The Equipment Commission is to approve all safety equipment sold within the State.

Brake specifications are set forth for trailers.

Loads must be securely fastened.

Many provisions relating to the rules and regulations of the roads and the highways refer to all motor-vehicles alike, and are similar to those already customary.

Speed of Trucks.—Motor-trucks with a gross weight over 3000 lb., equipped with pneumatic tires, are limited to 25 m.p.h. The new passenger or light-car limit is 40 m.p.h. For solid-tire trucks, speed limits are: 4000 lb., or under, 25 m.p.h.; 4000 lb. to 8000 lb., 20 m.p.h.; 12,000 lb., 18 m.p.h.; 20,000 lb., 16 m.p.h.; and 24,000 lb., 12 m.p.h. When trailers are used, the speed limit with maximum weight is 12 m.p.h., and with lesser weights is from 2 to 5 m.p.h. less than the higher speeds enumerated above.

State and Municipal Taxation

One of the difficulties with which operators of motortruck and motorcoach fleets have to contend is lack of uniformity in State motor-vehicle regulations, and some of these regulations should be modified. Although a reasonable degree of similarity among the various regulations for fleets has been brought about in recent years, a preliminary study on the West Coast indicates that many differences still exist in rules that affect both the operation and maintenance of automotive fleets. At present, three distinct methods of taxation are in effect against the truck operator in California. These are:

(1) An operator who operates motor-vehicles exclusively in local drayage business is required to pay the weight fees which are in effect during this year; namely, a fee of $10, $20, $30, to $40 for solid-tire trucks based on their unladen weight, and one-half of this amount for pneumatic-tire trucks. In addition, the operator must pay personal-property taxes and the required State license fees, and he must also report to the State Board of Equalization his revenue output from the city business; but such revenue should be reported as non-taxable.

(2) The operator conducting a general hauling business outside the confines of a single municipality, or not within the city, is subject, in addition to the weight fees and property tax enumerated in (1) for city operators, to payment of a 4-per cent tax on his gross receipts for such operation. He is permitted to claim credit for the license fees under various property taxes paid on said equipment, but not for weight fees paid to the State.

(3) All carriers operating as common carriers will be required to pay to the State a sum equal to 5 per cent of their gross receipts. Where the operator does not own and has not reported any operative real property, his taxes are now totally delinquent and subject to a 15-per cent penalty in addition thereto. His equipment is subject to sale and seizure by the State for the unpaid taxes. Where a common carrier has reported and has been allowed operative real property, the first one-half of his taxes is now delinquent and subject to the 15-per cent penalty; his second one-half is not due until 1928.

Inasmuch as the Wagy bill, which increases the pneumatic-tire-truck weight-tax from $5, $10, $15, and $20, to be $15, $40, $50, and $70, and the solid-tire-truck weight-tax from $10, $20, $30, and $40 to be $30, $80, $100, and $140, has been held up by referendum and cannot be made applicable until voted on by the people in 1928, it appears that the following system of taxation will be effective January, 1928.

California Common-Carrier Tax Situation

All common carriers will be subject to a 5-per cent tax and will be required to report in March, 1928, their taxable revenue for the year 1928, based on the gross receipts for the calendar year 1927, the same as common carriers were required to report on the 1927 taxable revenue in March, 1927, based on the gross receipts for the year 1926. Those operating otherwise than as common carriers will be required to pay only a weight tax of $5, $10, $15, and $20 on pneumatic-tire vehicles and $10, $20, $30, and $40 on solid-tire vehicles, in addition to their local license taxes and general-property taxes.

Inasmuch as the 4-per cent tax will be repealed after Jan. 1, 1928, an interpretation as to what constitutes a common carrier must be made by the State of California very soon relating to the matter of taxation, because the difference between the amount the State will receive upon determination of this question is very large. The law contemplates a tax of 5 per cent on the gross receipts of all common carriers, irrespective of whether the common carrier holds a certificate from the State Railroad Commission. It can be assumed that, for the purpose of gaining revenue for the State of California, those carriers who are common carriers in fact, regardless of what their claim may be as regards their operation, will be obliged to pay the tax as governed by the law and there will be a more rigid regulation of truck operation in the State in the future.

To give some idea of this, a new truck with a capital expense of $8,000 is figured for taxation on the basis of $4,000 for the first year. The tax rate is $6.10 per $100 and the first-year tax is $244; then a 50-per cent depreciation is allowed and the next year the owner pays $122. The second year the value is reduced one-half and the tax is $61 and, thereafter, so long as the truck lasts, the owner is billed each year for $61 and it is incumbent upon the operator to prove that this is too high. From the discussion by the West Coast Subcommittee, it seems that these fleet operators will have to compete with the small-vehicle operator, who pays a maximum of $15 State and city tax as compared with several hundred dollars that must be paid on the larger, better and more adequate vehicles.

San Francisco Regulates Truck Speeds

Four-wheel trucks are limited to a total weight of 30,000 lb. and six-wheel trucks to 40,000 lb. in an ordinance passed by the Board of Supervisors of San Francisco City, and the county speed-limit is 20 m.p.h. for trucks loaded to 12,000 lb., 15 m.p.h. up to 22,000 lb. and 12 m.p.h. for all over that weight. Violations are made misdemeanors with penalties of $300 fine or 3 months in jail or both. The ordinance is in conformity with laws passed by the State legislature last winter. It is the result of a campaign conducted by the city engineer's office of San Francisco and the favorable report of a traffic committee of the board of supervisors.

Fleet operators are often handicapped unnecessarily by

State legislation. The interchange of engines between vehicles, which is often required in fleet maintenance, can be accomplished in many States only after compliance with certain rules which may keep a vehicle out of service a week or so longer than is necessary to accomplish the change.

Choice of Equipment

The choice of equipment naturally falls on the maintenance division, which should specify the make and type of vehicle from operating data furnished by the operating department. The maintenance division must know the loads to be hauled, the speed desired, the topography of the country and the laws, and must have general information, so that the right chassis-specifications shall be recommended.

The make of the vehicle is not nearly so important as the specifications as to wheelbase, the distance back of the seat and many other dimensions and requirements in accordance with the operating conditions. A vehicle may have an excellent reputation and may cost more than other vehicles of the same capacity, but if it is overloaded through carelessness in weight distribution and driven beyond the speed for which it was designed, it is no better and no cheaper to maintain than the cheaper vehicle having the proper specifications.

Some factories are rather negligent in furnishing data to the fleet operator. We have in mind one factory in particular that almost resents the furnishing of engine-performance sheets and service data to fleet operators for their guidance.

Standardization Would Reduce Costs

Much can be done in the future toward reducing maintenance costs by standardizing certain features that seem to have nothing in common on odd makes of vehicle, yet function practically the same in most cases. Standardization, improvements and provisions for better accessibility would be advantageous to all concerned if something were done toward eliminating the present varied practices. Some of the desired changes are as follows:

Speedometer Drives.—A standard method of application to the transmission or drive-shaft

Head-Lamp Brackets.—A standard exists but it is seldom followed

Water-Pumps.—Much improvement might be made by choosing an accessible location and using a non-corrosive shaft and improved packing-glands. Some water-pumps are integral with the fan and some are located under the radiator; many are placed, as a last resort, anywhere that the type of construction will permit; some float on the shaft and others are bolted rigidly to the crankcase

Fans.—A standard fan-installation and the use of a standardized type of belt would be an improvement. V-shaped belts and flat belts are used, and there are gear-drive and many other types of drive and take-up. Some take-ups require a full set of tools and others require only a twist of the fingers for their adjustment

Thermostats.—The installation of thermostats as regular equipment is desirable, particularly on trucks

Engines.—Desirable improvements are five main bearings on four-cylinder engines, seven main bearings on six-cylinder engines, steel timing-gears with abjustment provided for take-up, carburized crankshafts, lubricated exhaust-valve stems and force-feed lubrication. All truck engines should have S.A.E. Standard openings in the clutch and in the timing-gear casing to accommodate starters and generators

Battery Boxes.—A battery box cushioned to accommodate the battery would reduce battery repairs materially. Many of the storage batteries removed from vehicles have been shaken to pieces rather than deteriorated by the current they furnish for lights and starting

Air-Cleaners—Considerable improvement can be made by having one central place on the vehicle to clean the air before it enters the crankcase or carbureter-air manifold. There is no question about the benefits of keeping abrasives out of the engine, but space for appliances is not always available.

Fuel Tanks.—A larger filler opening is desirable, to facilitate inspection and cleaning

Tire and Rim Sizes.—A reduction in the number of tire and rim sizes would be welcomed

Full-Load Auxiliary Springs.—Regular equipment would be advantageous on trucks

Specification Sheets.—A detailed specification sheet should be furnished with every truck chassis sold, the specifications being specific enough to help the operator to overcome the expense of dismantling units before he can order replacements intelligently

Brakes.—As speeds increase and traffic becomes more congested, the importance of increased braking areas is apparent. Whether the solution will be developed from four-wheel brakes or from some other arrangement remains to be worked out. Four-wheel brakes will distribute the braking stresses to better advantage than merely increasing braking areas by using larger drums, special braking material or additional propeller-shaft brakes acting on the rear wheels only.

Chassis-Weight Reduction.—The fleet operator is waiting for some reduction in chassis weights, not so much by the installation of undersized units but more by the aid of metal alloys and greater efficiency per pound of construction weight. The airplane manufacturer has demonstrated what is possible, particularly on engines, and it is doubtful if the fleet operator can continue to sacrifice pay-load to accommodate the chassis weights prevailing. Some of our present truck engines weigh as high as 35 lb. per hp. The fleet operator is making every effort for further weight reductions in his mountings to increase the pay-load and still be within the laws governing highway operation.

Changes in Construction

I would like to see the day come when factory managers would consult, or at least would notify, the fleet operator before making changes in construction and specifications. The fleet operator standardizes on some particular size of vehicle and goes to the extent of purchasing spare units for his fleet to safeguard his load factor; then, without notice or consultation, the manufacturer changes his models. The result is that the fleet operator is left with a large investment in obsolte units on his hands. Such practice is not fair, and the fleet operator loses confidence each time his favorite factory changes models of engines and other units that are not interchangeable with previous models.

Accounting Practices

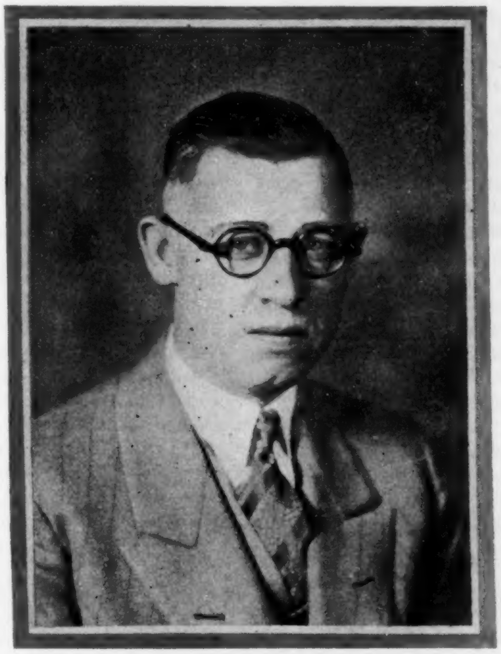
The West Coast Subcommittee has taken upon itself the prerogative of drawing certain general conclusions regarding cost accounting. However, these conclusions will not be presented in detail because the Subcommittee on Accounting has received reports on the various accounting systems of the large-scale fleet-operators on the Pacific Coast.

With one exception, the fleet operators keep segregated records of operating expense for the individual pieces of automotive equipment. The general segregation of these expenses into gasoline, oil, tires, repairs and general overhead is the same, although the detail of what enters into the

various subdivisions varies somewhat with the companies. The practice of charging for the use of the equipment on a mileage basis or on an hourly basis seems about equally divided. Arguments in favor of one or the other system seem to be based largely on the use made of the equipment, and no general rule should be urged for all companies. This feature is one of expediency to obtain the most correct charge for the use of the equipment and is somewhat outside of the realm of this report, which is concerned more particularly with keeping the operating costs of the equipment, regardless of how they may be cleared later.

The West Coast Subcommittee recommends that the first move that should be made toward obtaining the adoption by the various companies of records which will be comparable is to secure uniformity of accounting records and practices. It is more reasonable to expect comparable costs with companies all operating in California than it is to expect uniform costs from companies operating at widely separated points in the United States. This fact should assist in persuading companies that are directed by an outside agency that slight changes in their accounting procedure would enable the usual reports to be made and make them comparable with those of other West Coast companies.

If the various companies profess interest in the proposed general plan for unification of records, it is recommended that, through a series of conferences, a plan be worked out which can be fitted into the various systems with the minimum amount of change. It would be extremely wasteful of time and unproductive of result to attempt to lay out such a plan if the companies for which it is done are unresponsive to the effort.



E. C. Wood

Carburetion

Fleet operators on the Pacific Coast have been giving considerable thought to carburetion because they find that their fuel costs constitute from 13 to 20 per cent of the total cost. Practically all increases in efficiency effected in this respect must be obtained through either or both of two sources: (*a*) carbureter adjustment and (*b*) maintenance of proper mechanical condition of the powerplant. A few fleet operators employ men who have specialized in carburetion. The work of adjusting carbureters has been, and in most cases still is, performed by a man who has not been trained in the principles of carburetion. A tabulation of information furnished by a few large-scale fleet-operators on the Pacific Coast shows that a wide variety of results was obtained. Due consideration was given to data accompanied by statements of operating conditions such as topography, loads, climate and traffic conditions. Practically all the fuel-consumption data given in Table 1 consist of averages of more or less extensive fleets.

In some of the public-utilities companies in which labor-saving devices, such as winches, have been installed on motor-vehicles, the mileage per gallon obviously would be less.

TABLE 1—FUEL CONSUMPTION OF VEHICLES ON THE PACIFIC COAST

Kind of Vehicle	Miles per Gallon
Popular Light Car	15.00
$1,000-Class Cars	15.50
$1,500-Class Cars	14.50
1-Ton Trucks	9.00
2-Ton Trucks	6.00
3-Ton Trucks	3.75
5-Ton Trucks	3.00

A considerable amount of work has been done by these fleet operators to obtain better fuel economy. First, the standardization of the carbureters and the controlling of carbureter adjustments according to the results of an analysis for carbon dioxide, CO_2; second, the installation of efficient ignition-systems.

In obtaining the data, the various operators were questioned regarding their methods of obtaining the proper carbureter adjustments, as to whether laboratory tests were made on the fuel and whether an analysis was made of the exact causes to determine if the maximum results were obtained. In practically all cases, we find that little or no effort is being made on the part of the organization. A few operators probably have gone into the matter extensively and have made various analyses and practised the control of carbureter adjustments.

The varied topographical and climatic conditions that prevail in different parts of the Pacific Coast, and also the various types of equipment and carbureter, have placed the problem of carburetion in the provincial class. As special conditions can be handled best by recording instruments, the dynamometer is used to aid the fleet operator in obtaining efficient performance. As there are several dynamometers on the coast, the fleet operator has available a method of determining efficiently the fuel consumption in pounds per brake-horsepower hour. The development along this line has in many cases placed the fuel-consumption cost at the minimum and enabled the fleet operator to keep it within the economical fuel-consumption operating-range. Some engines consume more fuel for their actual power-output than others do, because of inefficient design, improper carburetion or ineffective manifolds. Gas fumes continue to be a source of complaints in various makes of motor-vehicle.

Equilibrium-Distillation Basis for Carbureters

Attempts have been made and are continuing to be made for the determination of the equilibrium volatility of the different gasolines. The reason for this endeavor is the recognition by the petroleum industry that the automobile engine uses gasoline of a quality that becomes vaporized under the conditions of an equilibrium distillation and not the quality produced by fractionation, such as is obtained in making the standard distillation test of the American Society for Testing Materials. This means that, when the gasoline is evaporated completely in an automobile engine, its equilibrium boiling-point is the best indication of performance. It is to be ascribed to defects in the average carbureter and in manifold design that this equilibrium distillation is not accomplished in the way it could be. It is our opinion that this is due mainly to poor atomization in the carbureter. While it is evident that the total gasoline used in the automobile engine forms equilibrium vapors after total evaporation, the vaporization of the individual droplet is not spontaneous, but consumes a time element proportionate to its size, other conditions being equal. Hence, atomization into the finest possible spray should be one of the requirements of every good carbureter.

To obtain good atomization, the air current passing the jet should move as fast as possible without offering too

much resistance to the intake, and it is also desirable that the air current and the stream of gasoline leaving the jet meet each other at as nearly a right angle as possible. These requirements are met in only a very few carbureter designs. In most of them the jet stands parallel with and in the center of the path of the air current, usually in a throat of fixed size in which the velocity of the intake air necessarily varies with the opening of the throttle.

Another feature frequently found in carbureters is an auxiliary air-valve which admits air to the already atomized mixture somewhere between the jet and the manifold. Aside from the fact that this air is not so effective in producing equilibrium evaporation as air admitted over the jet, on account of its shorter period of contact with the gasoline, it usually meets the main stream at an angle, deviating suspended gasoline droplets from their path and causing them to be thrown down on the walls of the passage. It is our opinion that a good carbureter should admit all air over the jet or jets, where it should meet the gasoline at a large angle, and that the flow of air over the jets always should be above a certain minimum required for good atomization. A few present-day carbureters of the floating-piston type come nearest to these requirements.

Another drawback of present carbureters is the difficulty of adjustment. There are very few that need only one or two regulating operations, many require the installation of new jets, the changing of float levels, or three or four different adjustments, to make them function well. This means that they are running in poor adjustment for the largest part of their use, as the average garage man or owner does not have sufficient knowledge of their construction to keep them operating efficiently. Much could be done in this respect by manufacturers of carbureters and motorcars, as some adjustment usually is necessary every time the carbureter has been dismantled for cleaning or for some other reason.

Principles of Carbureter Design

As to the general principles of design, it would be advantageous to provide carbureter characteristics which would give richer mixtures with a wide-open throttle than when the engine is running light. Highest economy is most desirable when cruising slowly, and this can be obtained by a mixture somewhat leaner than is theoretically necessary. Maximum power is desired when the throttle is open, and this can be obtained at the expense of economy by using a rich mixture. Many carbureters are made with total disregard of this simple requirement.

The increasing use of natural gasoline as a constituent of motor fuel presents a rather new factor in fuel characteristics which affects the functioning of carbureters. While this gives gasolines of very desirable qualities as regards starting from cold, acceleration and low equilibrium-volatility temperature, it may give rise to the formation of vapors in the carbureter which, when developed in sufficiently large quantities, may impair the proper functioning of the engine. To avoid this, the vacuum tank, the carbureter float-chamber and all gasoline piping should be kept away from highly heated engine parts and installed so far as possible in the air current generated by the fan. It is evident from the simplest calculation that very little aid in vaporization can be obtained from the small amount of heat which it is possible for the gasoline to absorb until it reaches its initial boiling-point, and that the safety of operation and freedom from annoyance resulting from a cool gasoline-supply and absence of gasing in the carbureter far outweigh the possible slight advantage.

Proper Methods of Lubrication

Scarcely any subject has been discussed as much among fleet operators and engineers on the Pacific Coast as the correct method of lubrication of vehicles. Considering the data submitted, the general opinion is that the failures are due to inadequate inspection and to inadequate or improper lubrication. It seems important, therefore, to all concerned with maintenance that inspection and lubrication be given due thought and that they be performed properly.

Some fleet operators are inclined to use oils that are much too heavy for the engine and to use an oil of a single grade or body for all the engines of a fleet of vehicles of various makes and models. These engines are widely different in design and perform varied services.

This practice may be an effort toward standardization or toward the convenience of dispensing the oil, but it tends to eliminate the training of men in scientific lubrication. Engine size and design differ widely, as well as the systems incorporated for the distribution of the lubricant within the engine; some engines are worked harder than others and, incidentally, all require oils of a body suited for their design and the work they perform. In many cases too heavy a grade of oil is used, with the apparent thought of reducing oil-consumption. Starvation, excessive carbon formation, hard starting and the proper distribution of oil in sufficient quantity to the respective bearing surfaces are not considered. As oils offer resistance to motion, those that are too heavy for a given unit offer excessive fluid friction which will show as of increased fuel-consumption.

To determine how many miles or how many hours a vehicle should run in service before a change of oil becomes necessary, a test was made on 24 pieces of equipment. The mechanical history of each was recorded and the units were given a test to determine the slippage in cubic feet per minute. The oils are tested weekly; for fire, flash, viscosity, dilution, and residue. By this method, the maximum life of the oil can be utilized and the lubricant can be changed before a failure arises.

In compiling some of the field notes on the failures of automobile lubrication, the following are not by any means all the failures but are the ones so frequently met with that they should receive consideration by all engineers whose designs are weak in these particulars. These failures are listed in the order of their importance from a maintenance viewpoint:

Rear Axle.—Lubricant leaks out. Axles should be designed to retain oil. The suggestion is made to use oil-slinger-type retainers

Transmission.—Lubricant leaks out. Plain bearings are not lubricated properly. When plain bearings are used on the jackshaft, the transmission housing should be arranged so as to deliver oil under pressure to these bearings through a drilled countershaft

Universal-Joint.—Lubricant leaks out. Progress is being made by some manufacturers in making tight universal-joints, but there is room for improvement

Shackle Bolts.—Their lubrication requires too much labor and should be from a central system using oil

Clutch.—The lubrication of the bearings of the yoke and similar parts should be improved

Fan.—Very few systems of fan lubrication are even reasonably good. Fan bearings should be included in the engine-lubricating circulating-system

Engine.—Lubrication is hindered by dead ends in the oil-circulating system because they collect grit. There should be no dead ends. Oil-grooving in many engines is still done without regard for the principles involved in producing oil-films. There is room for considerable improvement in the design of oil-grooves. Designers should give more thought to the oil-flow in the bearings and to the maintenance of an oil-film, and should avoid oil-grooves in the high-pressure areas. The introduction of oil at low-pressure points also needs improvement

Oil-Pump.—The recovery or the priming pick-up is too slow

Minor Defects

The elimination of pockets in the circulating system is needed, because they collect grit. The worst offenders are large plugged holes in crankpins and dead-end camshaft bushings. The injection-type system of lubrication needs further development. Complete removal of grit from the oil every time the oil goes through the pump and the circulating system is also desirable.

A few cases of oil leaks in the pinion housing have been called to our attention. These occur on cars having short pinion-shafts. Leaks of this type generally are caused by a defective oil retainer in front of the shaft bearing.

Reclaimed Oil

The reclaiming of lubricating oil is in the experimental stage with some companies on the Pacific Coast. It is claimed that the recovery is about 80 per cent and that the return on the investment for the process is more than 100 per cent, although at present no data are available to prove this claim. In one case an operator having 65 trucks is reclaiming the oil and says he is making more than 123 per cent profit on his investment.

Some operators in Southern California are using reclaimed oil. They report that it is more stable than the original oil because the less-stable constituents are taken out by the reclaiming process after the lubricant is first used.

Reclaimed oil was used in various cars for test purposes, but the reports received are incomplete.

Valves and Other Parts

The correct design and functioning of the valves and valve assembly of the automobile engine are major features of its successful operation. We find that about 70 per cent of engine trouble can be traced directly to the valves and valve assembly. If this unit assembly is not functioning perfectly at all times, the following conditions will result.

Of the troubles, valve burning is most prominent. The general trouble of valve burning lies not in the valve itself but in the valve seat and valve guide. It is due not only to the heat of the burning gases but to the combination of heat and friction of these gases as they are forced under the valve at a heavy pressure and at a terrific velocity.

In the manufacture of the engine-block, the chemical analysis of the iron has a wide scope as to physical characteristics as made by different manufacturers. The second operation is the machining, which introduces stresses; then comes the seasoning process. Thorough seasoning takes considerable time if the block ever becomes normalized to the extent that warpage and distortion will not occur; consequently, if it is under-seasoned the valve guide and valve seat shift off their center line and, where the tolerance in machining is of a commercial standard, we often find the valve seat wider on one side than on the other after the unit has been pulled down. This is caused by the valve hitting on one side first and then slipping over before it can become seated. This condition slows down the valve action and, at high engine-speed, the valve has not time to close properly before the tappet is starting to open it again. Consequently, under this condition the valve never becomes properly closed.

Width of the valve seat is important. With a wide seat the area is restricted at a portion of the time of closing the exhaust valve and the cylinder is not thoroughly scavenged.

Distortion in the valve and valve stem have a prominent part in causing misalignment of the valve so that it does not seat correctly. The most frequent cause is that the valves have not been normalized by a heat-treatment after machining. In a few cases on the Pacific Coast it has been noticed that, with alloy valves, the cylinder-block has acted as a lap in the grinding operation and small particles of abrasive have remained on the seat to collect the residue of the exhaust gas, causing an early valve failure. The gases develop sulphuric acid, H_2SO_4, the agent which causes stem corrosion and valve pitting.

At times the valve stem becomes stuck in the valve guide and we also find abnormal wear in the guide and on the valve stem. When the guide is installed at the factory it is placed at a right angle to the valve seat on the engine and the spring is placed to give a straight downward pull. Sometimes the valve warps away from the true alignment; then it binds and abnormal wear results. The oil and chemicals in the exhaust gases, combined with heat, are responsible for the majority of the cases in which the valves stick in their guides. It is interesting to note, on units operating in business sections, where the mileage is very low and the stops and starts per day are numerous, how the carbureter choke is misused and results in an early valve failure in such units. Most of these failures are cases of sticking valves; rarely do we find a valve seat burned or cracked.

Methods of Reconditioning Valves

The general method used on the Pacific Coast for reconditioning valves is that of truing up the alignment with pilot reamers and seat reamers. The valve is then machine-ground and is finished with an abrasive. The average width of seat is 1/16 in.

With the valve guide, two methods are generally used. Some shops replace the guide with a new one and then recondition the valve seat. Another method is the machining of the old guide to a true alignment and using an oversize stem. The claim for this method is that the old guide is seasoned and reduces warpage and distortion to the minimum.

Another condition that bothers some operators is that of the valve pounding the seat continually until a pocket is formed and the valve seat also becomes burned or cracked. This condition is generally taken care of by one of the following methods. An oversize valve-head is sometimes installed to meet this condition if the rupture is not deep. Another method that seems to have met with success is the welding of new seats in the block and then machining them. Some operators use alloys for valve seats. Still another method that has met with favor is the use of replacement valve-seats.

Cooling and Fuel Systems

Adequate cooling of the engine is of vital importance on the Pacific Coast where the temperature and barometric pressure may change within a very short driving-range. Engineers need to give special attention to the cost distribution pertaining to cooling systems, as it is possible to attain an altitude of about 5000 ft. within a few hours of driving and in the same length of time the other extreme of driving on the deserts, which are below sea level, can be reached.

Considering the abnormal conditions of topography and temperature, considerable scope exists for improvement in the design and capacity of the cooling systems. There is certainly much need of an early correction in the means of flushing and cleaning radiators, as the present provision of a small pipe-plug is inadequate.

So much has been written and said about manifold design that it is difficult to offer any new suggestions. However, while it is generally the aim of the engine designer to make the passage from the carbureter to the intake valve as short as possible, it is my opinion that the longer this passage is, the better is the chance for complete evaporation in the short time available. I believe that all heating of the mixture should be done in the manifold or in the carbureter housing beyond the jet, and that the temperature of heating jackets or hot-spots should be under the control of the driver. All manifold passages should be designed so that they drain back toward the carbureter; otherwise there is a possibility of some pockets filling up

with unvaporized liquid, slugs of which may be carried into the cylinders.

In general, manifolds on the average passenger-car are much better designed than are the carbureters, probably for the reason that they are made by the manufacturer of the car, whereas carbureters are purchased by him in the open market. How little attention is paid to this very essential part of the engine is evidenced by the fact that sometimes on the same make and model of car there are two or three makes of carbureter.

Reconditioning of Bearings

A rather erratic condition seems prevalent in connection with bearings. In some cases the bearings are over-oiled, the result being bearing leaks, especially in rear main-bearings. In other cases insufficient lubrication is the fault, and sometimes this results in scorching. The factories nearly always follow these cases of trouble with a bearing change-over. It seems that if more time were taken in designing the job, much trouble and expense due to bearing trouble could be eliminated. At present, many bearings must be reconditioned in the field.

One of the most difficult things with which the fleet operator must contend is the purchase of oils. No comparative standards exist to guide the purchaser. Greater cooperation between the factory and the operators is needed. At present, the best engineering data available from reliable oil companies is the only technical advice the operators have, and its range is too great for making comparisons.

Charts and guides for the instruction and the training of the men who do the oiling are desirable to help them to realize that, if lubrication is neglected, the adjustments and replacements will increase in direct proportion to the proper lack of lubrication. With the cooperation of the manufacturers, it is hoped that this problem will be minimized within a short time.

The opinion of the fleet operators on the Pacific Coast is that reground bearings should be used with discretion; that is, with consideration given to where they are located, to the age of the vehicle, and to the amount of labor involved in refinishing them. The only time that a reground bearing should be considered is in case the life of the equipment is practically exhausted and it is ready for replacement and the repair is minor. In such case or in cases along parallel lines it may be cheaper to use bearings of this type to cover the period of emergency.

Some of the common difficulties experienced with reground bearings are due to (*a*) fatigue of the metal in the races, in which case grinding does not recondition the steel; (*b*) to the fact that the tolerances vary; and (*c*) to other causes such as that sometimes the outer race of one type and the inner race of another type are used, their compositions being different, so that the radius of the groove differs and eccentricity and excessive friction result. Considering all these points, a reground bearing might give service, but no person could honestly guarantee it.

Timing-Chain Troubles

Many cases of timing-chain troubles have been called to our attention. The two most bothersome troubles are excessive chain-wear and excessive noise. We have found cases of excessive chain-wear to be due to oil dilution, which in turn was due to piston-ring and piston leaks. Excessive noise has never been eliminated in many cases; the trouble seems to be built into the job. Another trouble that seems prevalent is timing-chain jumping. The average life of a timing chain, derived from data received from various operators, is about 35,000 miles.

Changes Wanted in Power-Transmitting Parts

With the varied field of operations and varied road-conditions on the Pacific Coast, it is very difficult to make one design meet all requirements. This is demonstrated by a survey of the lumber industry in the mountain section and by the high speed of coastwise transportation, in both the hauling and the motorcoach fields.

For Pacific-Coast operation a transmission is needed in which the ratios can be changed to meet the requirement of the particular operation. As an example, if it were possible and practicable to change the gear-ratios, as is done in the differential housings, from a sub-range to an over-drive range, and if this could be incorporated in one gear-box, the manufacturer could supply the correct speeds to meet the condition at a much lower cost than for the installation of a complete unit which, in the majority of cases, has the fault of not having a great enough range.

In operating the heavier equipment we have not experienced much trouble other than those developed by negligence of the drivers. But in some of the lighter commercial-equipment we have had some very poor results, such as bearing failure and unsatisfactory service from the material for the gears; in fact, the whole design was faulty.

Recommended changes in design on clutches are (*a*) provision for better lubrication of the parts, (*b*) accessibility for adjustment, (*c*) greater efficiency of the linings or facings, (*d*) that the material of the discs have a greater length of life because the present material wears out too quickly, and (*e*) that the length of life of this entire unit be made greater because it is very short now and has a high maintenance cost.

The foregoing conditions are brought about primarily by density of traffic and the topography of the locality in which this equipment operates, according to questionnaires returned from Seattle and San Francisco.

The general opinion of fleet operators in regard to universal-joint failures is that they are caused by torsional stress, ordinary wear, and inadequate lubrication in some types using bronze bushings. Troubles with the propeller-shaft are attributed to inadequate diameters to take care of torsional strains and, in some cases, to extreme angularity.

In some cases the torque tube is of insufficient strength and the rivets are located too close to the edges. The mechanical fit of torque tubes should be held to closer limits.

Brakes and Brake-Lining Failures

Brakes present the most serious problem with which operators on the Pacific Coast have to contend. This is due largely to the topography of the country; but long-distance high-speed hauling and traffic congestion also have their influence. Brakes are designed primarily for stopping vehicles, but in the West we have to use them for controlling speed on long steep grades, and they do not stand up under this work.

On one run of the San Francisco municipal buses the brakes have to be relined completely every week. These brakes have ⅜-in.-thick linings of 0.60 per cent carbon and 0.10 per cent manganese-steel working against 0.40-per cent carbon drums. The longest service that has been obtained from these linings is 1500 miles, which is about 10 days' service. The average run is 4500 miles per month. On some of our equipment of ¾-ton size, using the best fabric linings, we could get only about 500 miles between relinings. In this case, the trouble could be traced to the stock drums furnished by the manufacturer, which are so soft and flimsy that in 500 miles the linings literally tore pieces out of the drums and ruined not only the drums but the lining as well.

We used to resurface these drums and reline every 500 miles, but we still had a great deal of complaint on "lack of brakes," squeaky brakes, grabbing brakes, and "no brakes." Our remedy was to install rigid drums of hard cast-iron or of various alloys. Our tests show that the wear on these drums is negligible, amounting to about 0.001 in. per 1000 miles as compared with resurfacing at 500 miles and complete renewal every 1000 miles. The lining shows the same improvement. We are still running

linings on these drums that have done over 6000 miles on trucks that we formerly relined or should have relined every 500 miles. We have also noticed on these jobs in which squeaks have been eliminated that the brake is very much easier to operate and, most important of all, we have to adjust the brakes only once every 3000 miles instead of every 3 or 4 days. On these same trucks we have also attempted the salvaging of the old drums by brazing onto them bands of saw steel, mounting the drum on the hub and turning it to a true concentric surface. This method gives a long-lived brake, although it is not so quiet as the cast-iron drums.

A company which operates a large fleet of passenger-carrying vehicles and freight trucks in Yosemite National Park reports that the longest life it has been able to get from any lining on the market is 650 miles. Brakes are adjusted daily. Drums are also replaced frequently.

Opportunities for Brake Improvement

The foregoing cases are merely examples of the battle on the Pacific Coast with the brake problem. We realize that in many instances the grades and hauls are unusual, and that the brake service is exceptionally severe. Consequently, we certainly feel that brakes are one of the most important parts to be improved. Our main object is not criticism but constructive development, so the points which we believe offer the best opportunity for improvement of brakes are enumerated herewith. We recommend:

(1) Substantial, non-vibrating, true, hard drums of maximum diameter for the wheel used

(2) Good, dense linings that do not glaze or harden

(3) A larger arc of contact between the linings and the drum. Some trucks show only 60-per cent contact on the outside brake and 40-per cent contact on the brake inside. This is a source of excessive wear that can be remedied by better placing of the supports

(4) Brake rigging that is designed for rigidity as follows:
- Stiff pedal-forgings
- Substantial pedal-mountings
- Equalizing shafts that are large enough to eliminate appreciable torsional deflections
- That the pull be applied to the middle of the equalizing shaft
- Straight shafts
- Straight pull-rods, especially avoiding diagonal pulls
- Self-lubricating bearings of generous dimensions
- Brake anchors that will withstand the torque of the brake without appreciable give

(5) That brake release and anti-rattling springs take as little as possible of the driver's effort. On one of the most popular cars the brake-rods were badly bent by the anti-rattling springs

(6) That the layout of the brake linkage be such as to eliminate the effect of spring deflection if possible. We are at present having considerable difficulty on this score. The tightening of the brake because of spring movement actually has caused the rupture of the brake-rods on one make of car in our own fleet

(7) That, if hydraulic brakes are used, provision be made for automatic compensation for leakage, automatic elimination of air and automatic compensation for expansion and contraction. Two of the newer cars take care of some of these requirements. Our wide range of climatic conditions within a few miles or in a few hours makes the expansion problem a particularly aggravating one in California

(8) That better means be provided for keeping axle or transmission oil off of the brakes. Consider the man-hours of maintenance time that is necessary to replace a worn felt on the rear axle or transmission

(9) That on heavy equipment the brake parts be of sufficient strength and be conveniently arranged for the application of boosters when the service requires them

(10) That more adequate protection of the internal brakes from road dirt be provided. On our hard drums we find that practically all the wear on the drums is caused by abrasive road-dirt riding between the drum and the band

To follow out this program completely probably will raise manufacturing costs slightly, but the Pacific Coast service managers and fleet operators would gladly exchange fancy trimmings for real brakes.

Front-Axle Camber and Caster

There is room for debate on the question of the amount of camber and caster suitable for cars to be used on roads in the Western States already mentioned. Regardless of what engineers say as to the proper setting for camber and for caster, we find that the operating companies which do wheel aligning themselves are changing the factory setting successfully. We also know of one large distributor who changes the factory's axle-setting as soon as the car shows the least sign of giving tire trouble. More information should be furnished regarding this important matter.

Tires and Tire Trouble

Operators on the Pacific Coast feel that it is vital to use pneumatic tires because of the increased speed and mileage attainable thereby in comparison with the performance of solid-tire vehicles, and in the report submitted they claim that the use of pneumatic tires has decreased maintenance and in some cases has resulted in better fuel economy. These statements are debatable.

To assure tire protection for both pneumatic and solid tires, operators have employed men as supervisors or inspectors to inspect tires, report when repairs are needed, determine whether tires are wearing properly, note whether wheels are in proper alignment and the like. A few operators follow this practice on a weekly schedule; others on a monthly basis. Operators of motorcoaches have such inspections made daily. According to the report, some tire manufacturers are selling equipment on the basis of tire mileage.

Overloading is conceded to be an important factor of tire cost over which the fleet operator has little control. Most operators are keeping records to determine tire performance and mileage per make of tire. No spare tires are carried on the cars of some companies. This reduces expense in two ways: First, not so much money is tied up by investment in spare tires that deteriorate with age and do not run their full calculated mileage when put into service; second, the expense due to theft of spare tires is eliminated.

The problem of getting tires that will fit rims snugly and have long life is a subject to which the fleet operators are giving some thought. It is surprising how little general information exists as to the right size of tires required for rims that are to carry a specified load. Tires of wrong size often are furnished and for a time they seem to do the work, but sooner or later there is expense which could have been avoided by utilizing proper information. Much constructive work can be done along the lines of providing the right tire for a given rim.

Analysis of reports from fleet operators on the Pacific Coast shows that 60 per cent of the failures are due to under-inflation, which is responsible also for a considerable loss in mileage. Most repairs to tires are necessitated by hitting curb lines and by depressions in the street which

cause cords to break inside the carcass and chafe a hole in the inner tube. The most common breaking point of the tire seems to be at the upper hinge of the tread. In wet weather most drivers let air out of the tires, claiming that it gives the tires more road contact and minimizes skidding. This results in breaking of side-walls and also causes a bruise, due to road contact, which results in premature ruining of the tire since such a bruise is beyond repair. The most common failures reported by fleet operators are due to neglecting cuts in the tire. Cuts permit dirt and water to enter, which causes tread separation and rots the cord. Overloading causes cords to check at the hinge point at both sides of the tires.

Balloon tires have made obsolete the high-pressure tire for light delivery-trucks and touring-car use, have increased tire-mileage by providing more road-contact, and have minimized skidding. The balloon type of tire should not be confused with the low-pressure tire.

Proper Inflation-Pressure Important

Drivers are inclined to carry only half enough air in their tires, primarily to secure more comfortable riding. This practice causes stone bruises and breaks the cords. It is a common occurrence in making tests to find that balloon tires which have been run under-inflated show a decrease in mileage of 50 per cent as a result. The upper hinge-point will not stand the strain and it gives way, due to flexing. Other tires of various makes give way at the lower hinge when under-inflated, causing the cord to separate about 1 in. from the bead. This injury is not reparable and is caused by the flexing at this point when stopping or starting. Other makes will break on the surface of the tire at the upper hinge, from over-flexing, and the cords eventually will break. Such a break we find not worth repairing, because the strain has been such that the tire will blow out within a very short time. The tendency of the new tires is toward increased mileage and the operators think 10,000 miles to be the average life of a tire in congested-traffic areas. This seems to be general for all makes, and every one interested can notice a desired change over the old type.

A few companies are retreading old tires and find the practice very economical. Some companies state that retreaded-tire mileage is equal to that of new tires. However, they watch the tire market closely; when prices are down they do less retreading and when the prices go up they do more retreading. Interesting figures on the cost of retreading as compared with buying new tires, and also comparisons of tire mileage, were submitted by fleet operators.

An Example of Overloading

A local operator was in the market recently for a 3-ton truck. In discussing his requirements with the truck-builder's representative, he stipulated that he wished to carry a 4-ton pay-load on this 3-ton equipment. This stipulation in itself was unusual for, in the majority of cases, the weight of the prospective pay-load is underestimated. The representative induced this operator to buy his 2-ton truck irrespective of the overload, and assured the operator that this 2-ton equipment, operating under the 4-ton weight-condition, would be satisfactory. The operator then called upon the tire representative to specify the proper tire equipment for this particular truck. After taking into consideration the weight of the vehicle, body, and the proposed 4-ton load, as well as the weight distribution, a 36 x 6-in. dual-tire was recommended. The truck was finally delivered with the tire equipment as ordered.

Standard equipment on this type of truck would have been a 36 x 7-in. solid tire on a felloe 6¼ in. wide. But the 36 x 6-in. dual tires were applied on this 6¼-in. felloe, which of course did not give the necessary support to the tires. The truck was loaded with the 4-ton load and could hardly move itself away from the curb. Undoubtedly, this was due partly to the extreme overload and particularly to the oversize of the tires. To have cut the tire size down would have remedied slightly the performance of the truck, but this would have meant a premature failure of the tires. Cutting down the load would have improved the performance of the truck greatly and at the same time would have made the oversize of the tires unnecessary. It should be remembered that, in this case, the operator originally wished to buy a 3-ton vehicle.

The operator complained to the truck builder regarding the truck's performance. The truck builder stated that the failure was not the fault of the truck, but the fault of the tire. The tire representative was called, the truck was taken to a scale and the weights were checked. The weights proved that, under these conditions, the tires were carrying the load within a safe margin of their maximum carrying capacity. In other words, irrespective of whether a 2-ton truck carries 2, 4 or 6 tons, it must have a tire which will support the weight of the truck itself and the weight of the pay-load, irrespective of what the specification for the original equipment may have been.

The cost to the operators today of tire mileage lost in the above-mentioned manner cannot be calculated accurately, but if it could be estimated the figures would be staggering. This loss can be overcome by the operator if he insists on wheels of proper felloe-width when he orders the truck. Truck builders can eliminate it by recommending the tire size adequate to carry the truck and the pay-load and a felloe-width that will support the tire properly.

The operators on the Pacific Coast are studying the following subjects in an effort to increase tire mileage:

- Use of heavy bodies
- Amount of overhang of the body over the rear axle
- Projection of the load over the rear tires
- Improper distribution of load
- Amount of crown of the road
- Frequent weighing under full load, to assure protection against overloading proper-size tires
- Regular inspection of brake assemblies for brake equalization.

Maintenance of Springs

The breakage of springs is not so frequent as it was formerly, due perhaps to a better knowledge of spring materials. Aside from overloading, the most general cause for spring breakage is *neglect*, particularly on the Pacific Coast, according to reports received from fleet operators. They say that neglect consists of two factors: not keeping the unit properly supported, and lack of proper lubrication. Either practice will not permit the spring to perform the functions for which it is intended.

Breakage at the center of the leaves is conceded to be due to loose clips; in fact, breakage through the center bolt-hole is taken as evidence by spring manufacturers that the spring-clips were not kept tight. However, it was the consensus of opinion of the fleet operators on the Pacific Coast that the spring-clips could be made much larger in every detail and thus would help in decreasing spring breakage.

Another contributing cause to high spring-maintenance was stated to be frozen spring-shackles. Some operators brought out the point that springs were handicapped by the misalignment of frames or axles and, according to their experience, set up sufficient strain to cause breakage.

Air springs are used by various operators. Specially constructed springs are designed and made on the Pacific Coast to meet certain conditions. Overload springs are installed on trucks because the operators feel that, although the carrying capacity of the trucks has increased approximately 75 per cent, the vehicles should possess easy riding-qualities under light-load or no-load conditions. This applies to the auxiliary springs designed solely as "helper" springs which function in that relation only to the present spring equipment. Some operators have found that this practice overcomes overloading, unequal loading, and road sway, and gives the needed additional carrying-capacity without sacrificing flexibility of the standard spring on the vehicle.

An analysis of the remarks of fleet operators on the Pacific Coast as presented in various papers is as follows:

The greatest trouble with springs is caused by overloading. A light spring overloaded soon loses its set and has to be reset. Heavy springs will not function when a truck is operated light.

Excessive loads under abnormal road-conditions perhaps have done most toward the development of two-stage spring-construction, most commonly called "side overload springs." In this construction a flat spring of semi-elliptical construction about two-thirds the length of the main spring is anchored to the top of the main spring and an ample perch is fixed to the frame just above the ends of the second stage. The distance through which the spring moves is governed only by the type of work the truck is doing and is by no means constant for all classes of work. This is also true of the number of leaves the second-stage spring may require

The foregoing type of overload-spring construction is very positive in its action. It not only serves as a safety device in cases of overload, but acts as a load stabilizer for extreme loads and for light bulky loads in traveling on grade curves. It acts also to prevent the shifting of the center of gravity of a load on either the rack or the flat-bed body construction. The most important function of this type of overload spring is the elimination to a great extent of the severe torsional stresses that are set up in the frame members of the unit under all conditions.

Motorcoaches on the Pacific Coast are going through a period of experimental spring construction. A single-stage semi-elliptical style of spring is being tried. A spring of remarkable resiliency has been developed. The length is about 52 in. for front springs and about 66 in. for rear springs, the width being 3 to 4 in. for front springs and about 5 in. for those in the rear. The thickness of the material varies from 9/32 to ¼ in. At full load, the deflection is about 1½ in. past the center position.

Body Construction and Painting

Several operators in the West conceived the idea of devoting more thought to the development of motor-vehicle bodies. I think the future will develop bodies designed to be better adapted to the special character of freight to be hauled or work to be performed. Study of special equipment will develop new fields for the motor-vehicle. This holds true also for trailer equipment.

Fleet operators throughout the Pacific-Coast territory are seriously considering ways and means of solving the problem of having to take their vehicles out of service for from 1 to 6 weeks every year for painting. It is a problem that affects both the large-scale and the small-scale fleet-operator. Experienced operators state that it is impossible to reduce the time consumed on high-grade finishes and claim that good painting and lettering is always justified, yet the element of time in keeping the vehicles idle at least 2 to 3 weeks cannot be overlooked. The question of whether it is practicable to have painting work done by outside shops involves consideration of such factors as the size of the fleet and the paint-shop facilities available.

The consensus of opinion is that operators should maintain their own paint shops because it is then possible to obtain proper supervision and to do touching-up work when necessary. One operator feels that it is necessary for him to have three jobs going through the paint shop at one time so that his shop will pay. Some companies are getting very good results from low-cost jobs and are accomplishing this work in from 6 to 7 days; others get the work done in 3 days. Some operators have spare bodies, and this has resulted in a higher load-factor.

Lacquer Used as a Time Saver

There is no question that the use of lacquers will have a tendency to decrease the idle time of equipment; from information received, this seems to be a fact. In discussing the good and the bad points of lacquer finish as turned out in factory production, we find the same result as in any other line of manufacture. Some of the custom lines are spending sufficient time and money to produce a result that is as near perfection of finish as is humanly possible, while the cheaper lines are more or less skimped both in time and material; and, as these are the jobs that come to our notice in a ratio of at least 10 to 1, the answer is very problematical as to whether the finish is a durable one. The great trouble with most of the work is that the foundation coats often are not of the proper kind and, even when suitable, they are force-dried to the extent that the life is taken out of them, leaving a very hard and brittle condition that has a tendency to chip and crack. To please the finisher, many manufacturers of surfacing materials have provided a surfacer having a too-easy sanding-quality; it lacks the proper amount of binder and therefore would, when thoroughly dried out, lack adhesion and elasticity.

A good oil-combined primer surfacer air-dried from 16 to 24 hr. according to shop and weather conditions is the ideal surfacer for building up for lacquer coats. If the surfacer has sufficient binder of itself, no sealer coat is necessary; but, with the great number of these surfacers on the market, some good and some better, a safe precaution is to apply a thin coat of emergency sealer prior to the application of the lacquer coats.

Pyroxylin surfacers, though extensively promoted and used, are not practicable in general practice on large areas of bare metal, as it is impossible to clean the metal to a state in which the proper adhesion is obtained. Moisture of the hand will deposit a film of grease that may cause the materials to peel off. When these types of surfacer are dried out for a few months, the shock of a slight collision will cause the finish to chip off clear down to the metal. The pyroxylin type of surfacer does, however, have a very important field in repair work over small surfaces and, on the finer work, as a hard surfacer to be applied over the oil surfacers prior to the application of the lacquer finishing-coats.

Unlike other finishes, lacquers wear by film thickness. The more coats of lacquer applied, the longer the job will stand up. In fact, lacquer wears until it is worn away by successive polishing operations. When the job has one less coat than is needed, the job is in the shop to be done over just that much sooner. For commercial work no job can be expected to give service with less than a minimum of three coats of lacquer and, on jobs to be rubbed out and polished, five to six coats are advisable. In the use of lacquer it is important to use the lacquer thinner made to be used with that lacquer, as a foreign thinner may cause the lacquer to bloom or blush, or throw it out of balance.

Refinishing of Lacquered Surfaces

Refinishing old lacquer jobs has been more or less a problem. It has not proved satisfactory in general practice to use a surfacer of any type over this class of work. The better policy is to clean the job thoroughly and then saturate the old surface by spraying a slow retardent thinner over it from two to three times, which will put back into solution the old surface and revive it with the substance that has evaporated from the film. Then proceed to spot-up breaks and abrasions with lacquer putty, or spot-spray with pyroxylin surfacer. Within about 2 to 4 hr., according to conditions, sand the surface with No. 400 paper and high-test gasoline; then clean the surface and respray the job. This method has proved the most satisfactory. When an old lacquer job is handled without taking the course outlined, the chances are that the lacquer will start to crack and split almost immediately. Refinishing old varnish and enamel work in lacquer is a very important item on both commercial vehicles and passenger-cars. It can be done with satisfactory results if the painter uses good judgment regarding the condition of the old surface.

Maintenance of Lighting Equipment

Under the California law certain specified lights are required on trucks from ½ hr. after sunset to ½ hr. before

sunrise. This law has been interpreted to mean that lights are not required on trucks operating only during daylight hours. Some operators take a chance and use no lighting equipment, but this is risky because the fines are heavy and a truck may be delayed until after dark.

Acetylene lights are legal under a clause that exempts them from the candlepower requirements applying to electric lights. As the cost of the gas is a major item of expense, acetylene lights are not much used for steady night running, but find their field on trucks that may be detained occasionally after dark. The maintenance cost is comparatively high, due chiefly to clogged burners and leaking hose.

Tail-lamp and dash-lamp equipment is particularly difficult to maintain. For steady night running, electric lighting equipment is practically universal. It is the most satisfactory lighting system, but is subject to some maintenance conditions that are worth mentioning.

In regard to incandescent electric lamps, the first thing noticeable is that they are provided with contacts of comparatively soft metal which has a low melting-point. These contacts sometimes wear due to vibration and sometimes burn out due to arcing caused by poor electrical contact. These troubles would not develop if it were not for the poor quality of the average electric-lamp socket. Poor design and poor material are the rule. It does not seem to be realized that an ordinary headlight lamp requires from 2½ to 3 amp. of current, or as much as an industrial 300-watt lamp. The contrast between the rugged socket used for industrial work and the molded miniature socket used on trucks is sufficiently striking even without taking into consideration the severity of the service to which truck lamps are subjected.

One point of design to be particularly condemned is the taking of current through small springs which hold the contacts in place. Generally, these springs are inadequate to carry the amperage and the consequent heating aneals the wire and makes it useless. Some reliance is placed on the contact between the plunger and tube, but corrosion soon puts this out of commission. Another point of design to be condemned is the tapping of minute screws through the side of thin tubing to secure the stranded wire. This design gives an insufficient number of threads and it is altogether too fussy for truck equipment. Further, a set-screw is a poor means of securing stranded cable, even with soldered tips.

Added trouble comes from hanging the weight of the wires from insecure fastenings. The wire should be supported in flexible conduit firmly attached to the lamps by a union nut or other means independent of the focusing adjustment, so that there is no possibility of the wires hanging from the socket. If the sockets were made substantially, of good material, had no springs carrying current, and were provided with clamp or soldered-wire connections, a large proportion of lighting troubles would be eliminated.

Lamps themselves give a good deal of trouble. They are usually too flimsy; rivets work loose, lenses rattle and slide around and the focusing arrangements shift and are difficult to adjust. The whole trouble with lamps seems to be due to building for low price instead of with high quality as an ideal.

Wiring should all be metal-armored cable, or placed in conduit and clipped solidly to the frame at frequent intervals. All connections should be soldered and care should be taken to avoid possibilities of chafing. Tail-lamp connections are particularly subject to trouble.

Standard switches give remarkably little trouble when correctly installed. Voltage regulators and battery cutouts give rather more trouble on trucks than on passenger-cars, owing to the greater vibration, and should be inspected frequently because failure may cause a burned-out generator or lights.

Generator brushes and brush rigging should be looked over regularly and generator bearings should be oiled at stated intervals. The generator leads a hard life on a truck and deserves some attention.

Upkeep of Storage Batteries

Next to lamps, storage batteries probably give the most trouble in heavy-duty-truck lighting-systems. They are an unmitigated nuisance, but often an unavoidable evil. The solution of the problem, if any, is to start with the best possible heavy-duty battery and service it regularly. The terminals should be kept clean and the electrolyte maintained above the plates. The battery should not be allowed to remain in a discharged condition, and any unevenness of voltage or of specific gravity between the cells should be corrected. This usually entails a battery overhaul. Several lighting systems are available which operate without a battery and, when conditions permit their use, they eliminate at least one element of lighting maintenance.

An entirely unnecessary amount of service work has to be done on truck lighting-equipment simply because the lighting systems are often nothing more than a passenger-car outfit wished onto a solid-tire heavy-duty truck which rattles it to pieces.

Air-Cleaners Reduce Wear

As to the value of air-cleaners, our experience proves that they remove dirt and dust before it reaches the carbureter. No question exists that damage from this source becomes negligible after an air-cleaner is installed. Actual tests by fleet operators have shown that on certain vital parts the wear is materially reduced.

Prof. A. H. Hoffman has made some very interesting tests of air-cleaners, and a bibliography covering this subject is printed herewith. In my opinion, Professor Hoffman should be given great credit for his work along this line.

Air-Cleaner Bibliography

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Oil-Filters as a Maintenance Factor

Actual tests reported by fleet operators have shown that oil-filters of certain types have reduced maintenance cost. We do not believe all the claims made for them but, insofar as they reduce maintenance costs, we consider them a very desirable accessory.

In Table 2, it is interesting to note in the tests of used oil the percentage of sediment, the amount of dilution and the recovery of the flash-point and the fire-point values after the removal of the diluent. This table shows that the oil-filter has a large field in which to operate. It is hoped that the development toward bringing oil-filters to a higher efficiency will continue.

Use of Governors to Lessen Maintenance

The small four-cylinder commercial car is rapidly being discarded. Present demand is for a small six-cylinder truck. This naturally increases the cost per unit and greater care is being exercised to protect and preserve this new equipment, as the cost per ton-mile is expected to be as low as that of the small four-cylinder truck, even though the cost of tires, body, repairs and parts, is much greater. The outstanding cost of maintenance is due to excessive and unnecessary engine-speed and vehicle speed. The small-truck manufacturer is not protecting his product against depreciation, and leaves it to the owner to install devices to curtail speed.

The large corporations on the Pacific Coast were the first to recognize the necessity of governing their motor-vehicle equipment. During the last 2 years fully 75 per cent of the small trucks have been equipped with governing devices. This has brought about a saving in many instances of as much as 50 per cent in maintenance. Tire mileage is greatly increased, due to slower movement of the truck. A sudden application of brakes at high speed causes more skidding of tires, and this also acts directly on the axles, transmission and engine. Excessive speed causes undue vibration of all parts of the chassis and body and is an important factor in rapid depreciation. One of the large-scale truck-operators declares that by using governors his cost of maintenance has been reduced to such an extent that he is now maintaining his entire fleet with one-half the mechanical labor required formerly.

Traffic regulations and speed laws are now observed more closely than in the past. A police department looks very favorably upon a corporation or truck owner whose trucks are equipped with governors. Officers of various traffic departments stated that personal-injury and property-damage claims are very few in fleets the owners of which govern their equipment. In one case a damage suit for $20,000 was dropped by the court because it was proved that a truck was governed to a maximum speed of 18 m.p.h. and the driver was exonerated from a charge of manslaughter and reckless driving.

The governor most popular on the Pacific Coast is a suction and velocity type. It is easily installed, has few moving parts and needs no lubrication. It can be attached to the engine without making any mechanical changes and costs but little. This governor will function properly at desired speeds and does not need to be renewed for practically the entire life of the engine. Mechanical or shaft-driven governors have been eliminated almost entirely because the first cost is greater. They require attention and lubrication and their maintenance cost often equals the cost of the device each year; whereas the combined suction and velocity type carries only a first cost.

Fleet operators on the Pacific Coast hope that manufacturers will make governors standard equipment on motor-vehicles used in fleet operations.

HIGHWAY TRANSPORTATION

Rapid Development by Motor-Vehicle Carriers Supplements Railroad Facilities

An interesting light was thrown by William H. Woodin, president of the American Car & Foundry Co., on the much-discussed question of the effects of the rapid growth in highway transportation on the handling of both freight and passenger traffic by the steam railroads, in the following remarks:

> The history of transportation, like all other history, moves in cycles. It may take centuries for the cycle to get back to its starting point, but the ultimate return seems inevitable.
>
> Good roads marked the beginning of civilization. Later, solid improved highways became a military necessity, as Julius Caesar found. He was the first great road builder, so that in England, France and Italy today some of the iron-clad roads laid down by his conquering legions are still in use.
>
> The first roads in our own Country, aside from the Indian trails, were carved out by the pioneers as the course of empire moved steadily Westward, and these roads they built, the Santa Fe Trail and the rest, pointed the way for the steel rails to follow.
>
> Not yet, perhaps, have the railroads, which made cities on the prairies possible, served their full turn; but now, when we have approximately 418,000 miles of steam railroads spreading a network over our entire Nation, representing with the necessary cars and locomotives and equipment an investment in railroad plant approximating $25,000,000,000, we find the cycle is coming back to its own; and once more the broad highway is coming to have an ever-increasing and perhaps a higher purpose in our social economy.
>
> The tremendous growth of improved highways all over our land has come about largely because of the development of the automotive vehicle of all classes. In 1926, the statistics show that there were produced, in the United States and Canada, passenger-cars to the number of 3,929,535, of a wholesale value of $2,622,450,000, and in the same period the produc-

TABLE 2—TESTS OF USED LUBRICATING OIL

Flash Point, deg. fahr.	280	205	160	210	205	185	200	190
Fire Point, deg. fahr.	445	280	170	240	255	205	285	245
Specific Gravity at 60 Deg. Fahr., deg. Baumé	22.1	27.4	26.6	25.8	22.7	27.5	20.5	24.5
Viscosity at 100 Deg. Fahr., Saybolt universal sec.	277	...	87.5	145	282.5	30.1	261.5	451.5
Viscosity at 210 Deg. Fahr., Saybolt universal sec.	51.0	...	40.5	44.0	54.0	56.5	53.5	70.0
Carbon Residue, by the Conradson Method, per cent	0.16	0.82	0.88	0.90	1.79	1.19	2.80	2.44
Ash, as Oxide of Iron, per cent	0.023	0.034	0.06	0.03	0.06	0.05	0.073	0.35
Acidity, in Terms of Mg KOH per Gram of Oil, per cent	0.21	0.48	0.58	0.37	0.30	0.25	0.50	0.36
Distillation to Determine Dilution, per cent	4.5	17.0	30.0	17.0	12.0	18.0	10.0	12.5
Flash Point, after Removal of Diluent, deg. fahr.	385	410	390	400	395	385	395	400
Fire Point, after Removal of Diluent, deg. fahr.	460	475	465	480	445	500	460	500

tion of trucks was 535,006, of a value of $434,500,-000; or a total combined value of cars and trucks of $3,056,950,000. But this is by no means the limit of the use to which our ever-increasing highways are put, for in 1926 approximately 15,000 motorcoaches and more than 43,000 motorcycles were placed in use. The total number of motorcoaches operated in 1926 throughout the United States was 79,806, with a route mileage of 607,793 miles. During the year they transported passengers to the amount of 2,395,000,000.

This increased use of the highways is a world-wide movement; the automotive vehicle has penetrated where railroads will never be known; in fact, perhaps the only land which has not reported one motor-vehicle or more, is Tibet.

How many billions the United States has spent for the building of improved highways is indicated by the fact that in the last 5 years there has been added to our improved highways approximately 250,000 miles, so that today we have 3,182,134 miles of improved roads. The Bureau of Public Roads estimates that in 1927 more than $1,120,000,000 has been spent by the States and their subdivisions on highway construction and repair.

DATA ON ANTI-FREEZING SOLUTIONS

Latest Information from the Bureau of Standards Herewith Made Available

The best available commercial materials for preparing anti-freezing solutions for winter use in automobile radiators are denatured alcohol, distilled glycerin and ethylene glycol. Table 1 gives practical directions from the United States Bureau of Standards for preparing a 1-gal. solution of each of the foregoing materials.

TABLE 1—DIRECTIONS FOR PREPARING 1 GAL. OF ANTI-FREEZING SOLUTIONS

Kind of Solution	For Protection at Temperatures of: Deg. Fahr. + 10 Pints	Zero Pints	— 10 Pints	— 20 Pints	— 30 Pints
Denatured Alcohol, 90 Per Cent, 180-Deg. Proof	2½	3	3½	4	5
Water	5½	5	4½	4	3
Glycerin, U. S. P., 95 Per Cent by Weight	2½	3¼	3¾	4¼	4½
Water	5½	4¾	4¼	3¾	3½
Radiator Glycerin, 60 Per Cent by Weight	4½	5½	6¾	7½	8
Water	3½	2½	1¼	½	0
Ethylene Glycol, 95 Per Cent by Weight	2	2¾	3¼	3½	4
Water	6	5¼	4¾	4½	4

Denatured alcohol solutions are at present the most generally used anti-freezing solutions. Denatured alcohol is widely distributed, affords protection against freezing and is not injurious to the materials used in the cooling-system. The principal objections to denatured alcohol are the loss of protection due to evaporation of the alcohol in service and the possibility of injuring the car finish if the solution or its vapor comes into contact with the finish.

Glycerin and ethylene-glycol solutions are initially more expensive than alcohol solutions, but neither glycerin nor ethylene glycol is subject to material loss by evaporation. These solutions are not injurious to the car finish under ordinary conditions. Before using a glycerin or ethylene-glycol solution the cooling-system should be cleaned thoroughly and the hose connections and pump packing tightened or replaced if necessary. The pump packing must be kept tight to prevent leakage of liquid and to prevent air from being drawn into the cooling-system.

Tables 1 and 2 and the foregoing discussion are based on the present edition of Bureau of Standards Letter Circular No. 28, in which salt solutions, such as calcium or magnesium chloride and sodium silicate; sugar solutions, such as honey, glycose or invert sugar; and oils, are shown to be distinctly less satisfactory for general use in automobile radiators than the previously mentioned solutions. A point frequently overlooked is that the use of any radiator solution containing calcium or magnesium chloride invites ignition trouble in case of leakage.

For ready reference, Table 2 also shows percentages by volume; quantities, in pints per gallon of water; and specific gravity at 60 deg./60 deg. fahr.

TABLE 2—READY REFERENCE ANTI-FREEZING-SOLUTION TABLES BASED ON DATA IN LETTER CIRCULAR NO. 28 OF THE BUREAU OF STANDARDS

Kind of Solution	For Protection at Temperatures of: Deg. Fahr. + 10	Zero	— 10	— 20	— 30
Percentage by Volume					
Denatured Alcohol, 180-Deg. Proof	30	38	45	51	61
Denatured Alcohol, 188-Deg. Proof	29	37	43	49	59
Wood Alcohol, 97 Per Cent	20	28	35	40	45
Glycerin, U. S. P., 95 Per Cent	32	40	47	53	57
Radiator Glycerin, 60 Per Cent	56	70	83	93	100
Ethylene Glycol, 95 Per Cent	25	33	39	45	50
Quantity, Pints per Gallon of Water					
Denatured Alcohol, 180-Deg. Proof	3.4	4.9	6.5	8.3	....
Denatured Alcohol, 188-Deg. Proof	3.3	4.7	6.0	7.7	....
Wood Alcohol, 97 Per Cent	2.0	3.1	4.3	5.3	....
Glycerin, U. S. P., 95 Per Cent	3.8	5.3	7.1	9.0	....
Radiator Glycerin, 60 Per Cent	10.0	18.7	39.0	106.5	....
Ethylene Glycol, 95 Per Cent	2.7	4.0	5.1	6.5	....
Specific Gravity at 60 Deg./60 Deg. Fahr.					
Denatured Alcohol	0.968	0.959	0.950	0.942	0.921
Wood Alcohol	0.975	0.966	0.958	0.952	0.945
Glycerin	1.090	1.112	1.131	1.147	1.158
Ethylene	1.038	1.048	1.056	1.064	1.069

BILLS FOR MOTORCOACH REGULATION

Regulation for motorcoaches engaged in interstate commerce, with primary authority vested in State commissions and with right of appeal to the Interstate Commerce Commission, is recommended in Congressional bills representing the viewpoint of 2100 affiliated operators, according to the Bus Division of the American Automobile Association. Senator Watson, chairman of the Senate Committee on Interstate Commerce, and Representative Denison, member of the House Committee on Interstate and Foreign Commerce, are sponsoring the bills as a preliminary step to securing the enactment of a suitable law at the present session of Congress.

The Interstate Commerce Commission has announced that oral argument on docket No. 18,300, dealing with motorcoach and motor-truck operation, has been assigned for 10 o'clock, Jan. 16, 1928, at the offices of the Interstate Commerce Commission in the City of Washington.

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Comparison of Methods of Measuring Knock Characteristics of Fuels

By GRAHAM EDGAR[1]

ANNUAL MEETING PAPER *Illustrated with* CHARTS

NINE laboratories employing widely different methods have cooperated in the measurement of the knock characteristics of five selected motor fuels. Considerable divergencies are reported in the results obtained by different methods, particularly for certain fuels, although there is reasonable agreement for other fuels. Laboratories using the "bouncing-pin" method have shown consistent results among themselves. No system of rating the knock characteristics of fuels is in use at present by which the results of different laboratories are readily comparable. An analysis of the data obtained from the nine laboratories is included herein, and possible reasons for the divergencies are discussed.

First reviewing the circumstances that led to the investigation reported in his paper, the author names the laboratories which cooperated, describes the sample fuels and how they were prepared, and outlines the method or methods practised by each laboratory and the equipment used. The experimental results are tabulated and are presented also in the form of curves to make their meaning clearer, the coordinates being chosen so that the difference between fuels Nos. 1J and 5J equals 100.

In his general discussion of the results, the author points out that two distinct problems are involved in the data he presents. The first is the rating of fuels in terms of the quantity of tetraethyl lead needed to make the fuels equal to a standard better than they are. This is an important problem but it is not an actual rating of the fuels themselves, since two fuels requiring the same amount of tetraethyl lead to make them equal a certain standard may not be themselves *exactly* equal, though they are probably *nearly* equal to each other. The second problem is the rating of the fuels themselves in terms of some other standard fuel to which an antiknock or benzol has been added, or in some arbitrary system. This point is illustrated by the data from the Bureau of Standards, in which fuels Nos. 2J and 4J2 require the same amount of tetraethyl lead to make them equal fuel No. 5J, but their ratings are 94 and 97 respectively on the maximum power scale. For this reason the two sets of data are considered separately.

METHODS that have been used for measuring the knock characteristics of fuels have included almost every factor known to be affected by the knock. For example, comparisons of fuels have been made in terms of spark advance, power, torque, throttle opening, speed and water-jacket temperature, as well as in terms of the amount of antiknock materials necessary to make the knock of two fuels equal. Little is known concerning the agreement or lack of agreement between these different experimental methods, since practically no data are available on measurements of identical samples of gasoline.

In October, 1926, a conference was held for the general purpose of discussing present methods of measuring the knock characteristics of fuels. Representatives of the Bureau of Standards, the General Motors Corporation, the Standard Oil Co. of New Jersey, and the Ethyl Gasoline Corporation were present. It was generally agreed that all present methods of measuring knock characteristics are essentially methods of *comparing* the characteristics of two fuels and, since each testing laboratory uses an arbitrary reference fuel, that no direct comparison of methods could be made without cooperative work on identical samples. It was therefore decided to prepare five samples of widely varying characteristics, and to ask the cooperation of a number of different laboratories in testing these samples by their own individual methods. Two problems were involved, (*a*) to determine how closely different laboratories may agree on the specific problem of rating samples in a certain definite way, and (*b*) to determine how well different methods of rating agree among themselves. All the laboratories which were asked to cooperate agreed and, after many delays, the project was carried out.

A brief preliminary report was prepared by me and was submitted to the various laboratories for comment and criticism. The present report represents an attempt to embody, so far as possible, the opinions of the various laboratories, together with my own analysis of the data.

The laboratories cooperating in these tests were the Armour Institute of Technology, the Atlantic Refining Co., the Ethyl Gasoline Corporation, the General Motors Corporation, the Standard Oil Co. of Indiana, the Standard Oil Co. of New Jersey, the Universal Oil Products Co., the fuel laboratory of the chemical engineering department of the University of Michigan, and the United States Bureau of Standards. These laboratories were selected largely because of the wide variety of experimental technique represented.

TEST FUELS USED

Five 1-gal. samples of each of five fuels were sent to each laboratory and these were numbered 1J, 2J, 3J, 4J2 and 5J. The nature of the samples was as follows:

No. 1J—Straight-run gasoline made from a known Mid-Continent crude oil

No. 2J—Commercial aviation-gasoline

No. 3J—Straight-run California gasoline of a type known to be high in antiknock value

[1] Director of research, Ethyl Gasoline Corporation, New York City.

No. 4J.—A sample made up of 70 per cent of No. 1J and 30 per cent of 90-per cent benzol

No. 5J—A sample made up of No. 1J plus ethyl fluid containing 3.5 cc. of pure tetraethyl lead

These samples were all specially prepared and do not necessarily correspond exactly to any commercial gasoline. They were chosen to give rather extreme types in which a maximum variation in the results of different testing methods might be expected. Distillation data and chemical analyses by two of the cooperating laboratories are given in Table 1.

TABLE 1—DISTILLATION DATA AND CHEMICAL ANALYSES OF THE FUEL SAMPLES

	Fuel Samples, Nos.									
	1J		2J		3J		4J		5J	
Specific Gravity, American Petroleum Institute Degrees	57.5		65.0		56.8		48.9		57.5	
Color No.	25		30		25		24		...	
Percentage Distilled Off at Temperature, deg. fahr.										
5	157		154		153		164		...	
20	202		178		204		182		...	
50	291		210		260		224		...	
90	389		290		347		387		...	
End-Point, deg. fahr.	433		370		396		426		...	
Carried Over, per cent	98.0		98.0		98.0		97.0		...	
Residue, per cent	1.0		1.0		1.0		1.5		...	
Loss, per cent	1.0		1.0		1.0		1.5		...	
Chemical Analyses	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
Unsaturated Hydrocarbons, per cent	3.5	...	2.9	...	1.3	...	3.4	...	...	...
Aromatic Hydrocarbons, per cent	5.4	6.0	0.0	2.5	4.6	6.5	45.2	33.5	...	...
Naphthene Hydrocarbons, per cent	17.6	17.0	32.4	29.0	35.4	34.5	13.2	11.0	...	...
Paraffin Hydrocarbons, per cent	73.5	...	64.7	...	58.7	...	38.2	...	...	...

Each laboratory was sent a small sample of ethyl fluid previously analyzed and known to contain 1.0 cc. of pure tetraethyl lead in 1.90 cc. of fluid. The laboratories were asked to determine by whatever methods they were in the habit of using the quantity of tetraethyl lead which must be added to samples Nos. 1J to 4J, to make the tendency to knock exactly equal to that of sample No. 5J, which had been treated with enough tetraethyl lead to make its tendency to knock somewhat less than that of any of the other samples; and the laboratories were not informed in advance of the exact nature of any of the samples. The laboratories were also asked to rate the gasolines according to any other system which they might be in the habit of employing. Through an oversight which was not discovered until too late to correct it, the Universal Oil Products Co. was not supplied with a sample of No. 5J, so that its data could be based only on its own rating system.

METHODS USED BY THE DIFFERENT LABORATORIES

The method used by the Armour Institute of Technology is described in detail in a paper by Daniel Roesch entitled Audibility Antiknock Tests and Knock-Intensity Evaluation[2]. A four-cylinder engine is used and the spark is advanced until detonation occurs. The fuels are rated according to the spark advance necessary to produce a knock of any given intensity as measured by ear. Data were reported from engines of two compression-ratios, 4.58 to 1 and 5.8 to 1. A Stromberg M1 carbureter is used, with the adjustments fixed for all fuels after the initial adjustment for laboratory-standard fuel. This corresponds to a mixture ratio of about 13 to 1 for the laboratory-standard fuel. Other fixed conditions are the temperature of the air inlet to the carbureter, 160 deg. fahr.; the temperature of the outlet jacket-water, 155 deg. fahr.; and the temperature of the oil in the sump, 125 deg. fahr. All temperatures are ±5 deg. fahr. The engine-speed is 1000 r.p.m. In comparing the fuels the spark advance necessary to produce a given knock intensity was plotted against the volume of tetraethyl lead in cubic centimeters and comparisons were made by interpolation of the curves.

The apparatus used by the Atlantic Refining Co. consists of a Lockwood-Ash four-cycle single-cylinder water-cooled marine-engine, a hand-operated Prony brake, an air preheater, and an externally operated water-pump. The cylinder is lined to make the bore 2⅞ in., and the stroke is 4 in. A water-cooled cylinder-head which gives a compression ratio of 6.5 to 1 is used. The Holley carbureter was replaced by a modified 1-in. Zenith carbureter, making it possible to get the same mixture for various throttle openings at constant speed. This mixture was set at 12.5 to 1 by weight of air to fuel for a reference fuel, which is Mid-Continent straight-run gasoline of United States Government specifications.

The other conditions are that the carbureter adjustment is the same for all fuels, the air is preheated to 140 deg. fahr., the outlet jacket-water temperature is 155 deg. fahr., the quantity of cooling water is constant, the spark timing is constant at about a 25-deg. advance, and the engine-speed is 1200 r.p.m.

The carbureter throttle is equipped with a needle which slides over a graduated scale as the throttle is opened or closed. The throttle opening at which detonation begins is taken as a measure of the knock characteristics of the fuel. Comparison is also made with the reference fuel to which varying amounts of benzol have been added.

The power unit employed by the Ethyl Gasoline Corporation is a single-cylinder Delco-light unit consisting of a 1250-watt standard set equipped with a special water-cooled cylinder and cylinder-head of the size designed for the 850-watt set. The compression ratio is about 6.4 to 1. A special carbureter of fixed-jet type with micrometer control is used. A special fuel-feed system is installed which permits a rapid shifting from one fuel to another, and independent adjustment of the fuel-air ratio is made for each fuel under test. The speed is held constant at 1000 r.p.m. The bouncing-pin

[2] See THE JOURNAL, July, 1926, p. 17.

method described in the paper by Thomas Midgley, Jr., and T. A. Boyd entitled Methods of Measuring Detonation in Engines[3] is used to determine the knock, and the two fuels are adjusted by the addition of ethyl fluid until an identical knock is recorded for the two.

The General Motors Corporation makes all measurements on a 3¼ x 4¼-in. single-cylinder variable-compression engine connected to a 15-hp. Sprague cradle-dynamometer. The temperature of the jacket-water is held constant by thermostatic control, and the engine-speed, as indicated by an electric tachometer, is maintained at 950 r.p.m. The fuel is supplied to a simple mixing-valve from a duplex float-bowl device which is adjustable for height relative to the fuel jet and which permits the air-fuel ratio to be regulated for maximum detonation. A three-way valve in the fuel line makes it easy to change quickly from one fuel to another without interrupting the operation of the engine. Determinations of tendency to knock are made by two methods. The first, and the one usually employed, is considered the more accurate. It embodies the use of the bouncing-pin indicator.

A general outline of the procedure of the bouncing-pin method is that the engine is first allowed to warm-up to equilibrium temperature. The compression and the spark advance are then adjusted to produce a fairly severe knock; that is, enough knock to cause the generation of 0.5 to 1.0 cc. of gas per min. in the burette of the bouncing-pin apparatus. Comparison of the knocking tendency of the fuel under test with that of the standard fuel is then made, and the quantity of tetraethyl lead that has to be added to the fuel under test to make it equal to the standard in knocking characteristics is determined.

The second method is based upon determination by ear, as the compression ratio of the engine is varied. The throttle is kept wide open and the compression ratio is increased to the point where detonation just becomes audible—called borderline detonation—at the maximum power-adjustment of spark advance and air-fuel ratio. The speed is held constant at 1000 r.p.m. The fuel under test is compared with the standard and tetraethyl lead is added to it until incipient detonation appears with both fuels at the same compression-ratio.

The equipment utilized by the Standard Oil Co. of Indiana is a Lockwood-Ash four-cycle single-cylinder water-cooled marine-engine connected with a Sprague electric-dynamometer. The bore is 2⅞ in. and the stroke is 4 in. The compression ratio is 6.5 to 1. A special Zenith carbureter is used which gives constant air-fuel ratios at different throttle-openings at constant speed independently of the fuel used, and the air-fuel ratio is 11 to 1. The power developed when light detonation occurs is taken as a preliminary measure of the knock rating and, for a final test, ethyl fluid is added until light detonation occurs at identical power-development and, therefore, at identical throttle opening, for the two fuels under comparison.

Method No. 1 of the Standard Oil Co. of New Jersey includes the use of three 850-watt Delco-light air-cooled engines, each having a different compression-ratio, which are equipped with special carbureters and mechanical brakes. All tests are made at a compression pressure sufficiently high to give a distinct knock. During a test the engine is operated on wide-open throttle at approximately a constant speed of 1350 r.p.m. The air-fuel ratio is set at about 13.5 to 1 by a carbon-dioxide, CO_2, analysis of the fuel used as a working standard. The bouncing-pin method is employed as a means of determining the degree of knock. Each test on the knock rating of an unknown fuel is made by direct comparison against a standard fuel with either benzol or tetraethyl lead added in known percentages. For instance, if the unknown sample should show on the average 2.35 cc. of gas generated in the electrolytic cell and should show by test that a blend of 30 per cent of benzol and 70 per cent of the standard fuel gave 2.32 cc. of gas, while a blend of 28 per cent of benzol and 72 per cent of standard fuel gave 2.43 cc. of gas, the unknown would be reported as having a benzol equivalent of 30 per cent. Comparisons using tetraethyl lead are made in the same way. For convenience in reporting results, a system of so-called knock ratings has been adopted, in which the standard fuel, which is a blended gasoline, is rated as 10, and in which 50 per cent of the same fuel combined with 50 per cent of benzol is rated as 0.

Method No. 2 of the Standard Oil Co. of New Jersey employs a high-compression automobile operating on a hill of sufficient gradient to give an audible knock at wide-open throttle. A direct comparison is made of the unknown fuel against definitely established standards. The listening method of comparing knock intensities is used. All tests are made at wide-open throttle and at an air-fuel ratio that will give maximum power. Different operators from those engaged in making the laboratory tests are utilized. The method is used primarily to check the laboratory tests.

The Universal Oil Products Co.'s method is described by W. F. Faragher and W. H. Hubner in their paper on Apparatus and Method of Rating Motor Fuels in the Order of Detonation[4].

At the University of Michigan the equipment used consists of a redesigned single-cylinder marine-engine made by the Hess Motor Co., Pontiac, Mich. The bore of the engine was reduced from 3¾ in. to 2 11/16 in. by inserting a steel sleeve inside the cylinder-block and using an Essex piston instead of the Ford piston regularly supplied. Special alloy-steel valves are used, and the cylinder-head was modified so as to raise the compression ratio to be approximately 7.3 to 1. The engine is directly connected to a 15-hp. electric-dynamometer; it is cooled by water pumped through the jacket and the cylinder-head, controlled by a constant-temperature thermostat. The air applied to the carbureter is preheated by an electric heater.

The regular method of making antiknock tests is to run the engine at a constant speed of 1500 r.p.m., at constant throttle-opening, a constant air-temperature of 45 deg. cent. (113 deg. fahr.), an inlet jacket-water temperature of 70 deg. cent. (158 deg. fahr.) and an outlet jacket-water temperature of 80 deg. cent. (176 deg. fahr.). The oil in the sump has a temperature of about 55 deg. cent. (131 deg. fahr.). Ignition is by means of a battery and a spark-coil. The distributor is modified so as to supply two sparks, one for igniting the charge in the engine and the other set at an angle of 180 deg. from it, or opposite it, on the timing shaft to cause a visible spark between a terminal on the flywheel and a quadrant to indicate the timing of the spark.

The carbureter is adjusted when necessary to supply the maximum power possible from the fuel being used. Operating under these conditions, the spark is adjusted between the limits of 4 or 5 deg. of retardation and 10

[3] See The Journal, January, 1922, p. 8.
[4] See The Journal, March, 1927, p. 405.

TABLE 2—CUBIC CENTIMETERS OF TETRAETHYL LEAD NEEDED TO MAKE THE FUEL SAMPLES EQUAL TO SAMPLE NO. 5J

Determined by	Fuel Samples, Nos. 1J	2J	3J	$4J_2$
Armour Institute of Technology, at Compression Ratios				
4.58 to 1	3.05	2.40	0.57[a]	2.50
5.80 to 1	3.40	1.89	0.79	0.94
Atlantic Refining Co.	3.00	1.50	0.50	1.00
Ethyl Gasoline Corporation				
Air-Fuel Ratio 12 to 1 for Each Sample[b]	3.50	1.25	0.70	1.30
Constant Float-Level[c]	3.50	1.35	0.35	0.85
General Motors Corporation, Equated by the Bouncing-Pin Method	3.60	1.30	0.70	1.10
Increasing Compression Until Detonation Begins	3.70	1.40	0.50	1.10
Standard Oil Co. of Indiana	3.05	1.90	0.25	1.90
Standard Oil Co. of New Jersey				
Standard Bouncing-Pin Method	3.70	1.40	0.60	1.40
Road Test in High Compression Automobile	3.80	1.60	0.70	1.40
University of Michigan	3.40	1.90	0.80	1.70
Bureau of Standards	3.42	0.80	0.25	0.80

[a] Best value. Readings, 0.25 to 1.10.

[b] At air-fuel ratios of 10 to 1 and 16 to 1, sample No. 4J2 required 1.3 cc. of tetraethyl lead; no similar determination was made for the other samples.

[c] Sample No. 2J is leaner than 12 to 1; samples Nos. 3J and 4J2 are richer than 12 to 1; and sample 5J2 is at a 12-to-1 ratio.

or 11 deg. of advance to get the maximum torque obtainable from the fuel under test. The position of the spark at which audible detonation is first noticed is recorded and usually occurs 1 deg. before the position of maximum torque. The torque is then plotted as a function of the spark advance, and the spark advance which gives a maximum torque is taken as a criterion of the antiknock value of the fuel.

As the object of most of the tests is to determine the relative antiknock value of different fuels, the basis of comparison used is a straight-run Pennsylvania motor-fuel of approximately United States Government specifications which was obtained in considerable quantity some time ago and stored in a low-temperature vault underground. The standard fuel is blended with different amounts of benzene of the rather pure quality used as a chemical reagent at the University. The antiknock values of fuels tested are reported in terms of benzol value obtained by matching the unknown fuel with the standard fuel blended with different amounts of benzol. It is generally unnecessary to make any carbureter adjustments to obtain the maximum power of the fuel. In no case was any change in adjustment made during the series of tests on the five fuels.

The test apparatus at the United States Bureau of Standards consists of a single-cylinder Liberty engine coupled to a Sprague 150-hp. electric-dynamometer and auxiliary apparatus for metering the fuel and regulating the cooling-water temperature. The engine has a special crankshaft and crankcase and the piston is crowned to give a compression ratio of 7.2 to 1; otherwise, standard Liberty aviation-engine parts are used. A straight horizontal intake-manifold about 1 m. (39.37 in.) long is connected to a Claudel twin-jet carbureter, one side of which is blanked off. Positive mixture-control is secured by means of a valve in the fuel line between the float chamber and the jet. Runs are made at a fixed spark-setting of about 30-deg. advance, which is the optimum setting for maximum power in the absence of detonation, and at a speed of 1500 r.p.m. Oil and water temperatures are maintained approximately constant but the intake air is not heated.

A series of runs is made at constant throttle with the reference fuel, using air-fuel ratios ranging from full rich to full lean, the throttle being initially adjusted so that detonation is audible throughout most of the mixture-ratio range but is not excessive at any carbureter setting. The maximum indicated-horsepower determined by these runs is termed the "maximum permissible-power." Similar runs are made at the same throttle setting with the fuel under test and the in-

TABLE 3—RATINGS OF THE SAMPLES OF FUELS IN OTHER WAYS THAN THOSE OF TABLE 2

Determined by	Fuel Samples, Nos. 1J	2J	3J	4J2	5J
Armour Institute of Technology.					
Spark Advance Needed to Produce Knock of Different Intensities. Compression Ratio 4.58 to 1					
Intensity A	5.7	10.5	16.8	16.0	29.0 28.5
Intensity B	10.5	15.7	22.7	21.0	37.0 38.0
Intensity B–C	12.7	18.1	27.0	25.0	42.3 44.0
Intensity C	15.3	20.5	32.0	29.0	52.5 56.0
Intensity D	19.5	25.2	32.7	38.5	....
Compression Ratio 5.8 to 1					
Intensity A	3.0	6.2	...	...	11.0
Intensity B	6.0	10.0	...	...	15.0
Intensity B–C	8.0	12.8	...	...	17.5
Intensity C	10.0	15.7	...	...	20.5
Intensity D	14.0	21.0	...	...	27.0
Atlantic Refining Co.					
Throttle Opening at which Knock Begins	7.6	8.3	9.1	8.7	9.7
Benzol in Its Standard Fuel, per cent	0.0	17.0	32.0	26.0	38.0
Standard Oil Co. of New Jersey					
Arbitrary Knock-Scale					
Engine Test	11.0	6.0	4.0—	6.0	2.0
Road Test	11.0—	6.5	4.0+	6.0+	2.0+
Benzol Needed to Make the Sample Equal No. 5J					
Engine Test, per cent	45.0	25.0	12.0	25.0	...
Road Test, per cent	47.0	27.0	13.0	26.0	...
Universal Oil Products Co.					
Benzol Required in Straight-Run Pennsylvania Gasoline to Equal Fuel Samples, per cent	12.0	48.0	47.0	40,0	...
Aromatic Hydrocarbons Equivalent from Analysis	10.5	8.7	13.8	49.2	...
Highest Useful Compression-Ratio (Ricardo), from Analysis[7]	5.17	5.11	5.26	6.34	...
University of Michigan					
Benzol Required to Be Added to the Standard Fuel to Equal the Sample, per cent	3.0	11.0	30.0	30.0	43.0
Bureau of Standards					
Percentage of Maximum Permissible Power, the Bureau's Reference Fuel Being Rated as 100	83.0	94.0	100.0	97.0	103.0

[7] See Determination of Unsaturated, Aromatic, Napthene and Paraffin Hydrocarbons in Motor Fuels, and Their Automotive Equivalents, by G. Egloff and J. C. Morrell, *Industrial and Engineering Chemistry*, April, 1926, p. 354.

TABLE 4—AVERAGE CUBIC CENTIMETERS OF TETRAETHYL LEAD NEEDED, AS DETERMINED BY THREE COMPANIES, COMPARED WITH THE THEORETICAL QUANTITY NEEDED

Determined by	Fuel Samples, Nos.			
	1J	2J	3J	4J2
Ethyl Gasoline Corporation	3.50	1.25	0.70	1.30
General Motors Corporation	3.60	1.30	0.70	1.10
Standard Oil Co. of New Jersey	3.70	1.40	0.60	1.40
Average Quantity, cc.	3.60	1.30	0.67	1.27
Theoretical Quantity, cc.	3.50	...	...	...

tensity of detonation is carefully noted. If there is less or more detonation with the test fuel, the throttle is adjusted until the detonation matches that obtained with the reference fuel and a third series of runs is made at the new throttle-setting. The maximum indicated horsepower developed by the test fuel at the final throttle-setting is compared with the maximum horsepower developed by the reference fuel at the initial throttle-setting, it being noted that these maxima do not necessarily occur at the same air-fuel ratio. Fuels are rated in terms of maximum permissible power on a percentage basis. Thus, in comparing sample No. 1J with the Bureau of Standards' reference fuel No. 10, a maximum of 20.5 hp. was developed by the test fuel and a maximum of 24.7 hp. by the reference fuel. Sample No. 1J is 17 per cent worse than this particular reference fuel and is given a rating of 83 with respect to fuel No. 10. The samples under test were also treated with ethyl fluid in sufficient quantity to equate the maximum permissible power to that developed by sample No. 5J as nearly as was possible.

Experimental Results

The quantity of tetraethyl lead necessary to make samples Nos. 1J, 2J, 3J and $4J_2$ equal to sample No. 5J is stated in Table 2, as determined by the several companies.

TABLE 5—COMPARISON OF ROAD-TEST AND BOUNCING-PIN METHODS OF DETERMINING THE QUANTITY OF TETRAETHYL LEAD NEEDED FOR EQUATING THE FUELS

Determined by	Fuel Samples, Nos.			
	1J	2J	3J	4J2
Bouncing-Pin Method, average cc.	3.60	1.31	0.67	1.27
Road Test in an Automobile, average cc.	3.80	1.60	0.70	1.40

Other Methods of Rating the Fuels

Several laboratories have rated the fuels in other ways than that reported in Table 2. These are as stated in Table 3.

Discussion of Experimental Results

Regarding the quantity of tetraethyl lead needed to equate the knock of each sample to that of No. 5J, we shall now discuss the following three methods: bouncing-pin; dynamometer, based on measurements of power; and dynamometer, based on spark advance.

As to the bouncing-pin methods, it is clear from Table 2 that the bouncing-pin operators agree rather well among themselves and with the theoretical value, 3.5 cc., for sample No. 1J, particularly when constant air-fuel ratios or air-fuel ratios for maximum detonation, are employed. For example see Table 4.

Each operator who obtained the results shown in Table 4 used a different engine and a somewhat different technique than the others. Identical air-fuel ratios were not employed, which indicates that, for the specific purpose of rating fuels in terms of the quantity of tetraethyl lead needed to equate the two fuels, the bouncing-pin method of comparison gives reasonably reproducible results. The average results also agree very well with those determined in an automobile on the road, indicating that this method gives results which duplicate to a reasonable extent the performance of an automobile. For example see Table 5.

If the comparison is made, however, at distinctly different air-fuel ratios for the two fuels under comparison, wider divergencies are noted. A leaner mixture requires more lead, and a richer mixture requires less. See Ethyl Gasoline Corporation method at constant float-level in Table 2.

In regard to dynamometer methods based on measurements of power, results of which are shown in Table 6, we note that the method of the Atlantic Refining Co. is not strictly a dynamometer method, since the load is absorbed by a Prony brake instead of a dynamometer; but at constant speed the throttle opening is essentially a measurement of power and the data therefore have been included with the others. They can be considered separately if desired. The average of the three dynamometer methods is not far from the average of the bouncing-pin results, but much greater disagreement is observed among the three results. Possible reasons for this are discussed later in this paper.

TABLE 6—RESULTS OF DYNAMOMETER METHODS OF DETERMINING THE CUBIC CENTIMETERS OF TETRAETHYL LEAD NEEDED, BASED ON MEASUREMENTS OF POWER

Determined by	Fuel Samples, Nos.			
	1J	2J	3J	4J2
Atlantic Refining Co., Air-Fuel Ratio 12 to 1	3.00	1.50	0.50	1.00
Standard Oil Co. of Indiana	3.05	1.90	0.25	1.90
Bureau of Standards	3.42	0.80	0.25	0.80
Average Quantity, cc.	3.16	1.40	0.33	1.23
Theoretical Quantity, cc.	3.50	...	...	...

As to dynamometer methods based on spark advance, the two methods in use are not strictly comparable, as the University of Michigan takes its rating from the spark advance for maximum torque and the Armour Institute of Technology takes its rating from the spark advance necessary to produce a knock of a given intensity. A comparison of the data with the average of the other methods is made in Table 7.

Concerning special methods of rating the fuels, considering (*a*) spark advance, throttle opening, "maxi-

TABLE 7—RESULTS OF DYNAMOMETER METHODS OF DETERMINING THE CUBIC CENTIMETERS OF TETRAETHYL NEEDED, BASED ON SPARK ADVANCE, COMPARED WITH AVERAGE RESULTS OF OTHER METHODS

Determined by	Fuel Samples, Nos.			
	1J	2J	3J	4J2
Armour Institute of Technology[a]				
Compression Ratios:				
4.58 to 1	3.05	2.40	0.57[b]	2.50
5.80 to 1	3.40	1.89	0.79	0.94
University of Michigan	3.40	1.90	0.80	1.70
Bouncing-Pin Method	3.60	1.31	0.67	1.27
Dynamometer Method	3.16	1.40	0.33	1.23
Automobile Road-Test	3.80	1.60	0.70	1.40
Theoretical Quantity	3.50	...	...	...

[a] The Institute states that the data on the engine having a 4.58-to-1 compression ratio are not reliable because the compression ratio was too low.
[b] Best value. Readings, 0.25 to 1.10.

mum permissible power", and "knock scale", as well as (b) benzol equivalents, the data have been plotted to make the results clearer, selecting the coordinates in such a way that the difference between fuels Nos. 1J and 5J is made to equal 100.

The fuels are plotted in the order of increasing antiknock rating, as shown in Fig. 1. The curves show that the ratings of these fuels give them in the same order, but there is much variation in the actual ratings. If all the methods were exactly equivalent, it is obvious that all the data could fall on a single line, and the difference between the ordinates for a given fuel shows the amount of divergence between the different ratings.

In regard to (b) the benzol equivalents, the data are plotted in a manner similar to that for Fig. 1, as shown in Figs. 2 and 3. In Fig. 2 the data are plotted as received. In Fig. 3 the data have been reduced to a definite standard, which is equivalent to No. 1J. This is probably legitimate except in the case of the Universal Oil Products Co., whose primary standard is clearly much different from the others. The data show wide divergencies, possible reasons for which will be discussed later. The benzol values for the Standard Oil Co. of New Jersey have been omitted from Fig. 3 since they are not ratings of the fuels in terms of the quantity of benzol needed to add to a standard fuel to make it equal to the sample, but are in terms of benzol to be added to the sample to make it equal to fuel No. 5J. In Fig. 4, the tetraethyl-lead ratings are plotted for comparison.

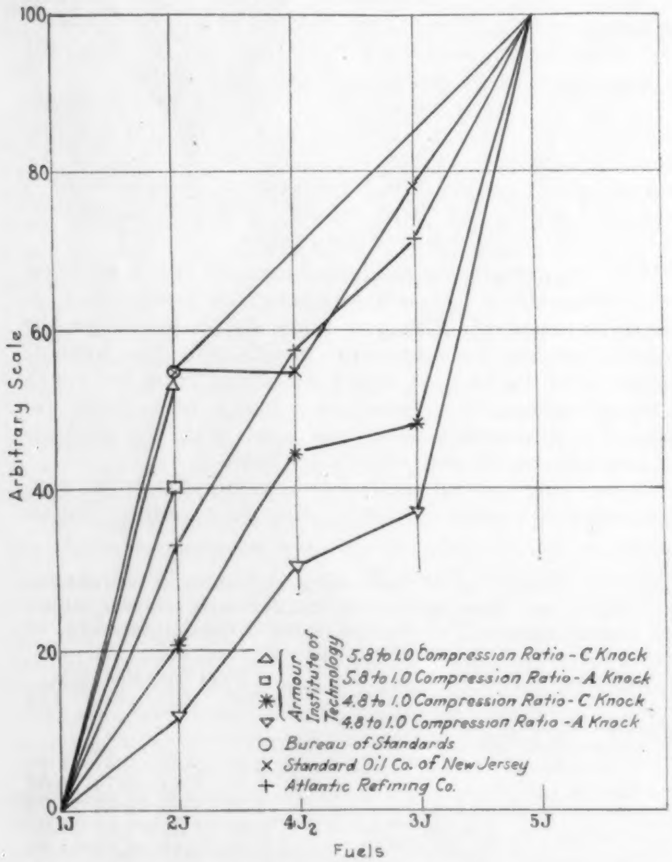

FIG. 1—DATA PLOTTED IN THE ORDER OF INCREASING ANTIKNOCK RATING

The Coordinates Are Chosen in Such a Way that the Difference between Fuels Nos. 1J and 5J Is Made To Equal 100. The Curves Show That the Ratings of These Fuels Give Them in the Same Order, but the Actual Ratings Show Great Variation

It should be pointed out clearly (a) that two distinct problems are involved in the data herein reported. The first is the rating of fuels in terms of the quantity of tetraethyl lead needed to make them equal to a standard better than they are. This is an important problem for the Ethyl Gasoline Corporation and others; but it is not an actual rating of the fuels themselves, since two fuels requiring the same amount of tetraethyl lead to make them equal a certain standard may not be themselves *exactly* equal, though they are probably *nearly* equal to each other. The second problem is the rating of the fuels themselves in terms of some other standard

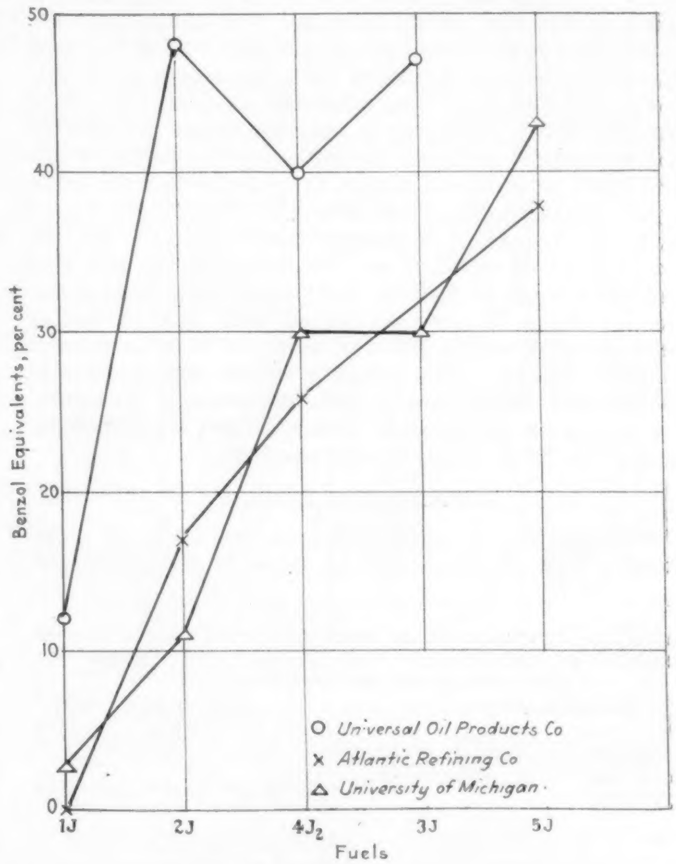

FIG. 2—BENZOL EQUIVALENTS, PLOTTED AS RECEIVED, IN A MANNER SIMILAR TO THAT OF FIG. 1

fuel to which an antiknock preparation or benzol has been added, or in some arbitrary system. This point is illustrated by the data from the Bureau of Standards, in which fuels Nos. 2J and 4J2 require the same amount of tetraethyl lead to make them equal fuel No. 5J, but their ratings are 94 and 97 respectively on the maximum-power scale. For this reason the two sets of data are considered separately.

In attempting to analyze (b), all the data on the specific problem of determining the quantity of tetraethyl lead needed to equate two fuels, nearly all the data have been plotted in Fig. 4. Certain general conclusions are obvious. First, all the experimental methods, with few exceptions, have given results which agree well among themselves and with the theoretical figure for the quantity of tetraethyl lead needed to equate fuels Nos. 1J and 5J. Second, most laboratories show a fair agreement on the quantity of tetraethyl lead needed to equate fuels Nos. 3J and 5J. Third, all labo-

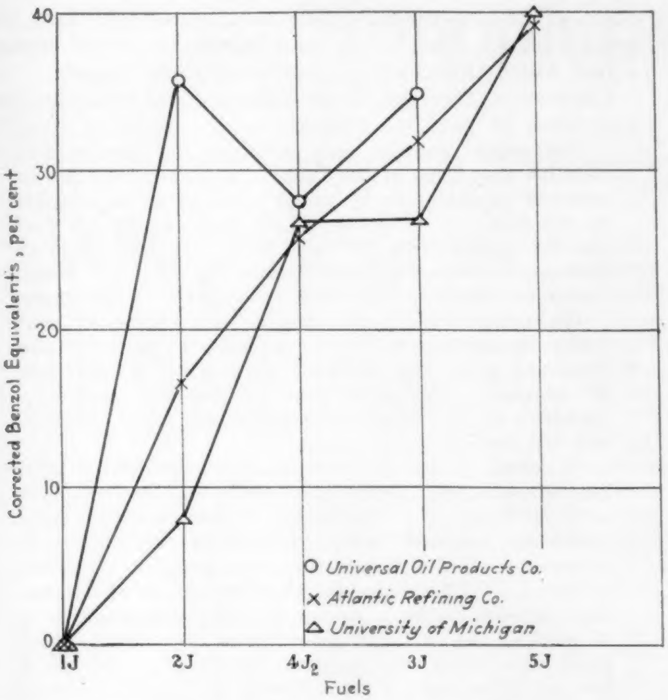

FIG. 3—BENZOL EQUIVALENTS, PLOTTED AFTER REDUCING THEM TO A DEFINITE STANDARD WHICH IS EQUIVALENT TO NO. 1J

ratories agree that the quantity of tetraethyl lead needed to equate fuels Nos. 2J and 5J and 4J2 with fuel No. 5J is the same or nearly so; but the actual quantity varies widely, between 0.80 and 2.4 cc. This is perhaps the most surprising result of the whole test, since these two fuels have properties varying in opposite directions from fuel No. 5J, and variations of air-fuel ratio and the like would be expected to affect the results in the opposite direction in the two cases.

Among the different operators, those employing the bouncing-pin method agree among themselves on the quantity of tetraethyl lead needed to equate fuels Nos. 2J and 4J2 with fuel No. 5J, which is about 1.25 cc. This does not imply that the bouncing-pin method is superior to the others. It is not surprising that the quantity of tetraethyl lead to be added to one fuel to make it match another varies with the conditions under which the two fuels are required to match. However, it is noteworthy that, by using the bouncing-pin method, the three different operating conditions used all lead to practically the same ratings for each fuel.

Regarding air-fuel ratios, the knock varies markedly with the air-fuel ratio and this factor therefore becomes an important variable. Four systems of measurement have been employed, as follows:

(1) Each fuel is adjusted independently to a constant fuel-air ratio
(2) The reference fuel is adjusted to a definite air-fuel ratio and the other fuels are employed at the same float-level or in the same carbureter
(3) The air-fuel ratio at which maximum detonation occurs is determined separately for each fuel and the comparison is made at this point
(4) Determinations are made at a number of air-fuel ratios and the rating is based on the maximum performance regardless of the air-fuel ratio

These differences in technique may account for many of the observed differences in results, particularly in the case of benzol blends. The advantages of the foregoing systems seem to me to be as follows:

Perhaps method (1) is the most reproducible, but it lengthens the time of a test and perhaps does not represent sufficiently well the performance of the fuels in an automobile in which the carbureter is not adjusted for different fuels.

Method (2) is the simplest and is similar to usual automobile practice; but perhaps it is more dependent upon the particular carbureter used. In using it, benzol blends will knock relatively less than with method (1), and fuels much lighter than the reference fuel will knock relatively more. See Ethyl Gasoline Corporation data at constant float-level in Table 2. If the air-fuel ratio is the same for all fuels under comparison, it appears that the actual ratio selected is unimportant. See Footnote 5 in Table 2.

Method (3) probably is reproducible, but it requires more time than method (2) and is not adaptable to every type of carbureter.

Theoretically, method (4) is perhaps the best in that it tends to give an absolute rating of the value of the fuel. Three great objections to the widespread use of this method are, however, (a) the elaborate equipment required, (b) the time required to conduct a test, and (c) the fact that the operating conditions differ so widely from those of an automobile on the road. For fuels of not too greatly different properties, method (2) is probably satisfactory.

Before any official method of determining knock char-

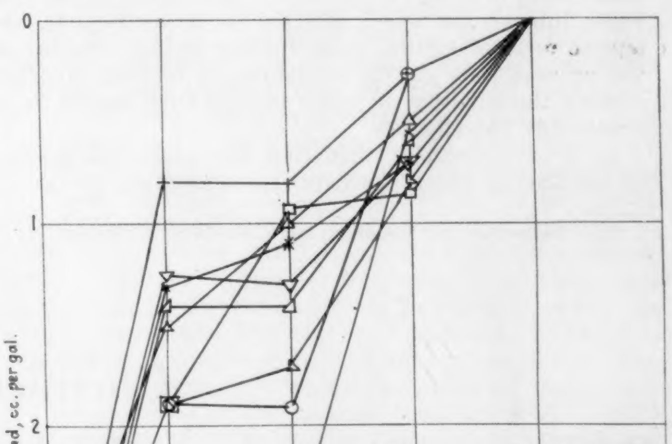

FIG. 4—TETRAETHYL-LEAD RATINGS PLOTTED FOR COMPARATIVE PURPOSES

acteristics is decided upon the air-fuel-ratio problem must be investigated further. It is clear that one objection to the use of benzol as a rating fuel is that variations in the air-fuel ratio are exaggerated.

The various dynamometer methods seem more likely to vary with variations in individual technique than the bouncing-pin methods, perhaps because of a greater sensitiveness to variations in air-fuel ratio, or because of other factors not yet determined.

Methods based on the spark advance necessary to produce knock of given intensity *may* show results at wide variance from the truth if the engine employed is not suitable for the fuels under observation. See the Armour Institute of Technology results on the 4.58-to-1 compression-ratio engine, Table 2.

From these tests it appears that considerable divergence is to be expected from the results of different methods of testing fuels, even on the specific problem of measuring the quantity of tetraethyl lead needed to equate them. It is also evident that the various scales for rating fuels used at present cannot be interpreted readily among different laboratories. Rating fuels in terms of two pure hydrocarbons, preferably as nearly alike as possible in their physical properties, should go far toward solving this problem. Mixtures of normal heptane and 2.2.4 trimethyl pentane seem ideally suited for this purpose. See Measurement of Knock Characteristics of Gasoline in Terms of Standard Fuel[8], by Graham Edgar.

If the reference standards of all laboratories are interpretable in terms of such mixtures, it seems probable that variations due to individual technique will be minimized, although such factors as control of air-fuel ratio, intensity of knock selected for measurement, and engine characteristics, need further study. So far as the present tests go, the bouncing-pin method of determining the equality of knock of two fuels seems to be reasonably satisfactory.

It is of interest to note that the analytical method of calculating knock characteristics, as given in the results of the Universal Oil Products Co., do not check the engine tests, either of its own laboratory or of others, a fact which this company has noted in its report.

Comments received from different laboratories are appended, in part, as follows:

> Carbonized engines may influence the results and relative standings of the fuels .... The errors can be reduced considerably by using a compression suitable to the fuel .... The ethyl-fluid requirement for fuel No. 3J varied from 0.5 to 2.10 cc. per gal.—0.25 to 1.10 cc. of tetraethyl lead—depending upon the knock intensity specified.—Armour Institute of Technology.
>
> We believe the point should be emphasized that every determination of the antiknock value of any unknown fuel must be made as a direct comparison, at as nearly the same time as possible, against a standard fuel of established antiknock value.—Standard Oil Co. of New Jersey.
>
> The rate of change of intensity of detonation with mixture ratio for benzol undoubtedly differs from that of other fuels .... The choice between constant mixture-ratio, constant carbureter-setting, and maximum power-ratio is the first step in standardizing a method of test .... The choice between indicators of detonation appears to be immaterial. The bouncing-pin is as good as the ear, and should have the advantage of being free from the personal factor .... Where a method is desired for reproducing one constant degree of detonation, as, for example, to measure the quantity of tetraethyl lead which must be added to a fuel to bring it up to *one* given antiknock standard, it is advisable to have all conditions on the engine protected against possible variation. The bouncing-pin method of indicating the same degree of knock is especially applicable to such a method.—Atlantic Refining Co.
>
> The fact that the Bureau found considerably less ethyl fluid required to make samples Nos. 2J, 3J and 4J2 equivalent to fuel No. 5J than most of the other laboratories suggests that the size and type of engine used may have more influence than the particular test procedure where, as in this case, a null method is employed.—Bureau of Standards.

Acknowledgment is made for comment and criticism from all of the laboratories whose work is contained in this paper.

[8] See *Industrial and Engineering Chemistry*, February, 1927, p. 145.

Chemical Warfare

THE gases of chemical warfare are extensively utilized in peace and, therefore, are always at hand for war. New potential war gases will inevitably evolve as a natural result of scientific research. Moreover, the development of poisonous gases is so closely connected with the dye industry that detection of the former is, practically, impossible. Chemical warfare products are, in some cases, identical with those of the organic-chemical industries. This flexibility of organic chemistry is an extremely important consideration and should be fully realized. In the words of Efisio Mameli, Italian chemist and professor in the University of Pavia:

> Since vast military arsenals are condemned, the surprise element in the future will be furnished by private industry, which cannot be restricted or abolished, since it lies behind all scientific and economic progress.

New war chemicals are likely to be discovered without any conscious effort in that direction. Chemical warfare is in its infancy; and probably every nation of leadership and foresight has, in reserve, concealed weapons of its own. The organic-chemical industry can swiftly and silently mobilize for war; and its possibilities for surprise are such that its importance as regards future wars can hardly be overestimated. Its power is so great that any nation able to spring a surprise similar to that of the Germans in 1915, only this time with decisive results, would, obviously, have the world at its mercy.

First and foremost, since the industries based on synthetic organic chemistry are so closely allied to chemical warfare, those industries must be fostered and the civil population educated as to their importance. This applies to every nation that hopes to retain or acquire a position among the leading powers of the world. In this twentieth century, well-developed chemical industries afford a better protection than mighty navies and imposing fortresses. It is obvious that, had the Allies, or America, possessed a flourishing dye industry at the beginning of the war, Germany's gas success could never have materialized, and thousands of lives would thereby have been spared.—From first-prize essay by Culbert Rutenber, in 1927 prize-essay contest of American Chemical Society.

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Monoplane or Biplane

By C. H. Chatfield[1]

Aeronautic Meeting Paper

AFTER pointing out that the rivalry between the monoplane and the biplane is of long standing, and that each must therefore have some advantages, the author proceeds to the consideration of the question at issue by comparing structural efficiency, aerodynamic characteristics, performance, and certain other features. In structural efficiency the biplane is considered superior both in strength-weight ratio and in rigidity, but the monoplane has the advantage of being better adapted to metal construction. In aerodynamic characteristics the monoplane has the advantage on the basis of wings of the same area and profile, but the lower lift-drag ratio and greater unit weight of the monoplane wing tend to reduce its superiority. World's records in performance are divided between the two types, and in speed the recent Schneider Cup races show the monoplane and the biplane to be about equal.

The biplane has the advantage in affording better vision and in smaller size, but is likely to be more expensive, except that it can be built of wood, whereas the monoplane would have to be of metal. The author does not attempt to draw a conclusion as to the general superiority of either type, but believes that the decision in any individual case should rest on the circumstances of that case.

RIVALRY between the monoplane and the biplane dates from the very beginning of flying with heavier-than-air machines. The biplane of the Wright brothers was soon followed by the French monoplanes, and in all the intervening years the two types have existed side by side. It is reasonable to suppose, therefore, that each type has certain advantages, and the purpose of this paper is to consider briefly wherein these advantages may lie. I shall confine myself to outlining the factors which may enter into such a comparison, leaving the citation of individual cases to those who have had more experience than I in airplane design.

It is evident at once that many factors must be considered in the discussion, for no one characteristic can be taken as an all-embracing standard of comparison. The points to be touched upon, however, may be grouped under the general headings of structure, aerodynamics, performance, and certain other characteristics which do not bear directly on any of the first three.

The comparison of structures is naturally in terms of weight of structure required for a given total airplane weight at a given load-factor, and this is chiefly a question of wing weight. With certain relatively minor exceptions, which will be mentioned later, the weight of other items of the airplane structure is not greatly affected by the wing arrangement. On this basis of structural efficiency it is evident that the biplane will ordinarily have the advantage. In fact, this advantage is the principal reason for using the biplane. To say that the biplane wing structure is a truss and that that of the monoplane is not would be superficial, for in reality both structures are trusses if we grant that, in a general sense, even a plate girder or an I-beam may be regarded as a truss.

Biplane Has Structural Advantages

The essential difference between the two types of structure is that the biplane truss has the greater depth in proportion to its length, for in the biplane the depth between the upper and the lower chords of the truss is essentially the gap between the wings, while in a monoplane the corresponding truss depth is merely the ordinate of the wing itself at the point where the truss is located. It is therefore evident that, for equal external bending moments, the chords of the trusses in a monoplane must carry much greater loads than do the corresponding members in a biplane. Since for equal wing-areas the monoplane will have the greater span, the bending moment due to the external load is ordinarily considerably greater in the monoplane than in the corresponding biplane. This naturally tends to increase still further the already heavy loading of the chord members of the shallow monoplane truss.

Another and perhaps more common view of the situation is expressed in the statement that the monoplane members carry bending loads while those of the biplane carry end loads. This is not strictly correct, for, even in a pure cantilever monoplane, the wing spars are likely to be built-up trusses, so that the individual members are subjected principally or wholly to end loads. If the monoplane has any external bracing, portions, at least, of the spars will be subjected to external end-loads in addition to the bending load. The wing spars of the biplane also are subjected to bending loads from the air forces, and these bending loads may be of equal or greater importance in determining their size than are the end loads imposed on the spars by their function as members of the external wing-truss.

From whichever point the situation is viewed, the structure of the biplane is the more efficient, and it is therefore to be expected that, in an ordinary case of two airplanes of equal size, of the same general type of construction, and designed to the same load-factors, the biplane wing structure will be the lighter. Studies of airplane weights show that in biplanes the complete wing cellule weighs normally from 1¼ to 1¾ lb. per sq. ft., while in monoplanes the weight of wings and any bracing commonly ranges between 1⅝ and 2½ lb. per sq. ft. Some of this difference, however, is due to the greater prevalence of metal construction in the wings of monoplanes.

The Biplane Is More Rigid

In addition to being superior to the monoplane in strength-weight ratio, the biplane structure has the advantage of greater rigidity; for, with equal stress intensities in the truss members and consequently equal

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strain, the angular deflections of the structures as a whole are obviously less where the depth between chords is greater. The greater rigidity of the biplane is effective both against loads that act symmetrically about the transverse centroid of the structure and against loads that tend to produce torsion, and in the latter respect the deeper structure of the biplane wing-cellule has an even greater advantage.

To a certain extent a monoplane designer can overcome this handicap by employing an airfoil with small center-of-pressure travel, but ailerons are still needed, and with them it may be found that the so-called stable wing has a center-of-pressure travel not much less than that of an ordinary wing. It is a common observation that aileron control is more likely to be bad on monoplanes than on biplanes, and probably the explanation of this lies in the lack of torsional rigidity in the monoplane wing and the consequent inability of the combination of wing and aileron to produce sufficient rolling moments on the airplane as a whole. This lack of torsional rigidity in monoplanes probably explains also some well-known cases of wing flutter.

However, granting that the biplane structure is the more efficient with similar types of construction does not end the discussion on this point, for the monoplane seems to lend itself better to types of construction that are desirable from points of view other than that of pure structural efficiency. Some years ago, when wood was the chief structural material for wings and no metal was used except for tension members and fittings, the biplane was much more the dominant type than it is today; but the tendency toward metal construction of wings has certainly been accompanied by a noteworthy increase in the proportion of monoplanes.

It is likely that the very structural efficiency of the biplane has counted against it in this respect, for in biplane wing-spars the load may be so low that a metal spar designed only for these loads would be deficient in local strength and would be difficult to manufacture because of the lightness of the sections employed. In this case, if the structure is to be practical and is to stand up in service, the members must be heavier than the stress analysis requires. Consequently, the strength-weight ratio is decreased and a considerable part of the superior efficiency of the biplane structure is sacrificed. This results in a tendency among designers to adhere to wood construction for biplanes, as with this material the members may approximate closely the sizes required by the stress analysis without the use of excessively thin sections. It should not be forgotten, however, that several modern and highly successful monoplanes have wings of conventional wood and fabric construction, though these generally have not been designed to high load-factors.

Parasite Resistance Is Less with Monoplane

In comparing the aerodynamic characteristics of monoplanes and biplanes, it may safely be said that, if the same airfoil is used in both, the advantage undoubtedly will be with the monoplane on account of the reduced parasite resistance and the elimination of interference between the wings. The monoplane, to have a reasonably efficient structure, requires a deeper wing than the biplane, and therefore the monoplane airfoil is usually not quite the equal in aerodynamic characteristics of the biplane airfoil. A comparison of the characteristics of three well-known wings is shown in Table 1.

TABLE 1—AERODYNAMIC CHARACTERISTICS OF REPRESENTATIVE WINGS[2]

Name	Maximum Lift Coefficient	Minimum Drag Coefficient	Maximum Lift-Drag Ratio	Maximum Thickness, Per Cent of Chord
USA-35	0.00383	0.000062	17.0	18.4
Clark-Y	0.00318	0.000038	21.2	11.7
RAF-15	0.00261	0.000032	20.3	6.75

[2] For this and other aerodynamic data, indebtedness is acknowledged to the staff of the Aeronautical Research Laboratory at the Massachusetts Institute of Technology.

The USA-35 is a wing for a pure cantilever monoplane, the Clark-Y is popular both for semi-cantilever monoplanes and for single-bay biplanes, and the RAF-15 is a thin wing, suitable for biplanes only. It is evident at once that the Clark-Y is nearly the equal of the RAF-15 in most respects while the USA-35 is distinctly inferior in all aerodynamic characteristics except maximum lift. These relations provide a reasonable explanation for the popularity of the semi-cantilever monoplane wing and also for the adoption of the long-bay biplane wing, in which the increased spar-depth available has made possible an increase in length of bays, with consequent reduction in number of interplane bracing members, so that the parasite resistance is decreased with comparatively little increase in wing drag.

It is interesting to carry this study a little further in an attempt to estimate the resistance of monoplane and biplane wing cellules for airplanes otherwise alike. Since the monoplane wing ordinarily will have a higher maximum-lift coefficient and a higher unit weight than the biplane wings, the comparison can be valid only if allowance is made for both of these differences. To take a concrete example, the DH-4B biplane, which has a two-bay cellule and RAF-15 wings, has a total drag of 930 lb. at 123 m.p.h. Of this total, 505 lb. is due to the wings. If the usual cable interplane-bracing is replaced with streamline wires, the wing-cellule drag is reduced to 365 lb. A cantilever monoplane wing, with the allowances mentioned, would have a drag of 330 lb. The total airplane drags for the three cases would then be 930 lb., 790 lb., and 755 lb., respectively. The total drag of the monoplane is thus about 5 per cent less than that of the better biplane; not a startling reduction.

Similarly, for a typical modern single-seat fighter having Clark-Y wings and a single-bay cellule, the total drag at 160 m.p.h. is 830 lb., of which 390 lb. is wing drag. According to the methods described, the drag for a semi-cantilever monoplane wing with its bracing is estimated at 340 lb., and that for a pure-cantilever wing would be 350 lb. The total airplane-drags would then be 780 lb. and 790 lb., respectively, for the two monoplane arrangements. The reductions from the drag with biplane wings are 6 per cent and 5 per cent, or about the same as in the first example considered, and these again are not especially noteworthy.

Other Aerodynamic Differences

Several other points should be noted briefly in the comparison of aerodynamic characteristics. Aileron action is likely to be less effective on thick airfoils than on thin ones, even though there is no additional reduction of aileron effectiveness due to torsional wing-deflection in the case of the thicker monoplane wing. Since the chord of the monoplane wing ordinarily is greater than that of the corresponding biplane wing, it

is evident that the movement of the center of pressure on the former is greater than on the latter, even though both may be the same percentage of the wing chord. Therefore, it is likely that the monoplane, if it is to be the equal of the biplane in stability and control, must have larger horizontal tail-surfaces; and it would not be surprising if larger vertical surfaces were required also, on account of the greater span of the monoplane. It is known too, that in several cases the effectiveness of the horizontal tail-surfaces of a monoplane has been reduced by the blanketing effect of the thick wing, so that further increases in the comparative size of the monoplane tail-surfaces were required to secure satisfactory control and stability.

Although maneuverability is likely to be better in the biplane, certain biplanes have been subject to the dreaded and highly dangerous flat spin, a defect from which monoplanes seem to be free. An objection to monoplanes that has had considerable force in the past is that their wings could not be built with aspect ratios equal to those of biplanes, but with the improved types of construction now available this objection has lost much of its force.

In addition to its direct aerodynamic superiority, the monoplane wing has the indirect advantage that its greater thickness permits locating within it such objects as tanks, which in a biplane might have to be placed in the wind at the cost of increased parasite resistance. While the magnitude of losses due to interference between wing and fuselage is not very well known, it seems evident that such losses do occur and that they are appreciable in amount. In this the monoplane may be expected to be at an advantage because the number of interferences is reduced. If it be not of the parasol type, the monoplane avoids the losses due to the usual small gap between the top of the fuselage and the bottom of the upper wing of a biplane.

Each Type Holds Performance Records

It seems worthwhile to refer to the relative performance of the two types of airplane separately from their structural and aerodynamic characteristics, because to a large extent the performance expresses the resultant of the structural and aerodynamic efficiency. Here particular statistics might be quoted to prove almost anything, but it may be pointed out that, just now, the records for range and endurance are held by the monoplane, while the altitude record and several of the combination speed-and-load records are held by biplanes. The results of the Schneider Cup race in 1927 indicate that, in the matter of pure high speed, there is not much to choose between the two types.

Direct comparison between corresponding airplanes is difficult, because the differences between typical monoplane and biplane types generally include other features than wing arrangement and so introduce enough additional variables to make the whole result indeterminate; but, even if performance does express resultants of structural and aerodynamic efficiency, there are still other characteristics to be considered. In many cases one of these other characteristics determines whether the airplane is to be a monoplane or a biplane.

From the point of view of size, the biplane ordinarily will have a substantial advantage. It would be very unusual for its span to be greater than that of a corresponding monoplane. On this account, the biplane is in most cases to be preferred if hangar space is limited. This consideration is paramount in the case of airplanes that must be stowed between decks on an airplane carrier. The designer of a semi-cantilever monoplane may overcome the handicap of greater span by making its wing folding. If, as in a popular American monoplane, the span with wings folded is no greater than that of the tail surfaces and the folded wings do not extend aft beyond the tail surfaces, this type of monoplane is substantially on a par with the biplane. Furthermore, it seems easier to design folding wings on a braced monoplane than on a biplane. If it is to be taken down for storage and reassembled for service, the monoplane has the advantage because the smaller number of members to be removed makes these processes shorter.

Biplane Affords Better Vision

As to vision the biplane probably has a general superiority that is especially apparent in military single-seaters, all of which, in this Country and in Great Britain at least, are of the biplane type. For commercial service, where all-round vision is not such a vital necessity, the monoplane may not be much inferior to the biplane. In the low-wing monoplane the downward view of the passengers is likely to be very poor, but this is largely a psychological objection and probably is not very important.

In respect to safety, there seems not to be a great deal to choose, but, except for the parasol type, monoplanes with open cockpits are much more dangerous than biplanes in a nose-over. One manufacturer of low-wing monoplanes stresses the effectiveness of the wings in preventing injury to the occupants in case of a bad landing, but the lower wing of a biplane probably is as effective in a similar situation. On the other hand, exit with a parachute should be easier from a monoplane than from a biplane.

Special types of interplane bracing lend themselves readily to the use of wide-tread landing gears or of twin floats on a biplane, an advantage which the monoplane ordinarily does not possess. Furthermore, except in the low-wing type, the provision of wing floats is rendered difficult with the monoplane because of the great height of the wing above the water. In many cases sponsons or stub wings have been used in place of wing floats, but it might be said that an airplane of this sort is really a biplane, or at least a sesquiplane.

Qu?

More than one engine usually can be supported with less additional bracing, and consequently with less increased parasite resistance, in the biplane than in the monoplane; but successful three-engine monoplanes are numerous, and in some of them the outboard engines rest directly on the wings. There are also ingenious arrangements of landing-gear struts and engine-mounting supports on monoplanes that combine the advantages of wide-tread landing-gears with three engines.

Monoplane Cheaper in Metal Construction

In all of these comparisons the vital question of cost has been left untouched. The monoplane has fewer wing panels; fewer fittings; fewer, if any, external bracing members; and usually has a simpler aileron-control system. It is therefore to be expected that, in similar types of construction, the cost of the monoplane will be less than that of the biplane, but it may be possible to use in the biplane the cheaper wood construction in place of the more expensive metal. This may make the biplane cheaper than the monoplane in

first cost, though possibly not in net total cost if depreciation is considered.

It would be very gratifying if the relative importance of the variables entering into the final result could be evaluated in a summary and a general conclusion drawn therefrom. While this might be done in specific cases, it can hardly be done in general in the present state of the art. I must therefore be content to finish without passing from the general to the specific. However, the monoplane evidently is gaining and there seems to be a distinct tendency among builders developing new and original types of construction to give most of their attention to monoplanes.

I trust that the discussion may bring to light some of the specific examples that are lacking in this paper, and that designers and constructors who have had experience with both types of airplane, particularly those who have changed from one type to the other, will be willing to give us the benefit of their observations, especially the reasons for their choice of type in specific cases.

THE DISCUSSION

ARCHIBALD BLACK[3]:—This question of biplanes versus monoplanes seems to be one of the riddles of the universe; I suppose we shall never have it settled. Regarding the two types from an operating viewpoint, we must consider the initial cost of each type, the relative facility of maintenance, the cost of ordinary maintenance, the cost of crash repairs and the ease with which damage from a forced landing may be repaired.

CHARLES WARD HALL[4]:—It seems to me that the weight allowance Mr. Chatfield makes between monoplanes and biplanes is rather high. I cannot see any great difference in wing-structure weight between a single-bay biplane and a braced monoplane. With the same plan form for the wings of two machines of the same gross weight, the monoplane will have approximately 1.4 times the chord of the biplane, and an equal ratio for the spans. The larger wing allows many elements to be loaded to capacity, whereas in the small wing many items are designed for bulk alone. An allowance of 8 or 10 per cent more weight for the braced monoplane wing than for the single-bay biplane wing seems to be sufficient.

A DIRECT COMPARISON

I. SIKORSKY[5]:—Last year and this year we produced, during spare time in our factory, some wings for existing airplanes. Last year we built biplane wings and this year we changed to monoplane wings having only slightly smaller area, because the monoplane wing in this case seemed to be a little less expensive. We tested them on several airplanes last year and this year, and the comparison in test was quite accurate because we used the same airfoil section and a similar method of construction in both. We could find no appreciable difference in performance between the two types under these conditions.

WILLIAM B. STOUT[6]:—This problem, like any other in airplane design, depends on what result is sought. In some cases the biplane fits and in other cases the monoplane fits. A wise designer takes the thing that fits the case, without prejudice.

As has been said, the consideration of metal has had some influence toward the design of monoplanes. Our choice of the monoplane type was largely because of the possibility of using metal. The early monoplanes failed on account of structural reasons. Monoplanes of the war period had 300 or 400 wires above and below to steady the wing spars, and they had to have a very low aspect-ratio, with the result that their performance was very poor.

Since the war we have learned to make the thick wing from various materials by using the skin of the wing as a part of the structure to keep the wing from fluttering. With cloth-covered wings it has been necessary to use out-riggers, that is, outside braces, to hold the spars in place and to prevent flutter, but using the skin, of veneer, metal or other material, as part of the structure gives to the wing inherent strength and torsional rigidity.

The statement was made that the thinner wing is used because it is more efficient. Possibly that is true, but I doubt it. For commercial work, lift is more important than high speed. A wing lifts by virtue of the amount of air it displaces and a thick wing will displace more air than a thin wing. The profile drag of a section amounts to very little. I remember going about 55 m.p.h. with Ralph Upson once in a 60-hp. blimp. The gas furnished the lift and the profile drag of the big bag amounted to very little. It is the same with the thick-section wing. If it is designed correctly for the cruising angle, there is no reason why a thick wing, within the customary reasonable limits, should not be as efficient as a thin wing, or more efficient. The thicker the wing at its root the lighter can the structure be made, and yet there is a point where even that ceases to be a virtue.

There is an advantage in being able to carry the gasoline in the wings, away from the engine and the cabin, and in having space enough to use circular tanks so they can be made of duralumin. It is hard to make welded square tanks of duralumin stay tight.

Mention was made of the aileron action. That we get through the tapered wing-section. If a monoplane wing is made with a thick section throughout, the aileron action is rather slow and the induced drag from the vortex at the tip is considerable, but a tapered section gives a very good, smooth and snappy aileron action.

Other commercial advantages of the high-wing monoplane are apparent when it is used month after month in regular service. With a bumper around the door, a truck can be backed underneath the wings right up to the door for loading and unloading, with very little trouble from careless drivers. Once in a while the truck bumps into the bumper but it hurts nothing. Great care is needed to avoid damage in using a truck for loading and unloading a low-wing plane. These things sound trivial, but in transferring loads many times a day, with truck drivers to whom an airplane means nothing at all, the maintenance cost is seriously hindered or helped by the location of the baggage door. So there are items other than engineering to be con-

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[4] M.S.A.E.—President and chief engineer, Hall-Aluminum Aircraft Corporation, New York City.

[5] President, Sikorsky Aero Engineering Corporation, College Point, N. Y.

[6] M.S.A.E.—Vice-president and general manager, Stout Metal Airplane Co. division of Ford Motor Co., Ford Airport, Dearborn, Mich.

sidered, and the choice between the biplane and the monoplane depends on the problem at hand.

Three Advantages of Monoplane Stated

JOHN G. LEE[7]:—There are three points I should like to mention, two of them concerning the passenger, as the plane of the future will be a passenger plane in most cases. First, the view from the cabin of a monoplane is much better than from a biplane, and that is one of the pleasures of flying. As a rule, the passenger cabin of a biplane is above the lower wing and the passenger cannot look directly down on the ground.

Something psychological in favor of the monoplane is second. A neat-looking machine with good workmanship will always attract passengers and it gives them a feeling of security. A monoplane such as Mr. Stout's or Mr. Fokker's looks simpler than it is.

Third is the matter of cost. The monoplane has fewer parts than the biplane. For instance, a small monoplane has fewer ribs than a biplane with the same wing area. The cost of ribs is small, but the cost of assembling them is enough to give the monoplane an advantage. Future planes will be required to have interchangeable parts. It is relatively cheap to jig a few points accurately in relation to one another, and that is in favor of the monoplane. A steel fuselage shrinks when welded and the fittings must be designed so they can be drilled and reamed in jigs after welding. That is done on the assembly floor and it holds up the production line.

Metal construction, which has come with monoplanes, and the fact that we are now entering upon the time when we want production, will have an effect upon the choice between monoplanes and biplanes. I dare say that for the smaller machine the tendency will be strongly toward the monoplane. What the tendency will be in the larger machines is still a question.

The Low-Wing Monoplane Advocated

J. OTTO SCHERER[8]:—This seems to be a discussion dealing only with the high-wing monoplane versus the biplane. The low-wing monoplane has not been mentioned and, from the comments already made, it seems to class with the biplane rather than with the high-wing monoplane. I am partial to the low-wing design for several reasons. The claims for the high-wing monoplane are good visibility from the cabin and immunity from trucks backing into the wing. Another frequently mentioned feature is the easy access to the cabin.

If truck drivers are so reckless as to back into the wing, they can hardly be expected not to back into the fuselage as well, and the fuselage will not stand any more abuse from the rear end of a 1 or 2-ton truck than will the wing.

I am willing to grant that the vision downward from the cabin of a low-wing monoplane is not so good as from the cabin of a high-wing monoplane. It is even a little poorer than from the cabin of a biplane, but, from my experience on the airways of Europe and on long trips in this Country, the passengers lose interest soon after the start in what is happening on the ground and either begin to read or go to sleep.

The low-wing cantilever monoplane has, however, a few important advantages that are appreciated only after extensive experience with this type. The typical high-wing monoplane has the bad habit of trying to go over on its back when being taxied in a heavy cross-wind. This characteristic is so well known that, when such a machine lands at a European airport on a windy day, the pilot does not try to taxi to the operator's office until he has a mechanic holding each wing-tip with a pike-pole. When a low-wing machine comes in on such a day, the pilot taxies the machine in unassisted, and experience has shown that he is safe in so doing.

The fact that the wing, which constitutes about 20 to 30 per cent of the total weight of the empty airplane, is about 4 ft. nearer the ground in the one case than in the other, or less than half as high, means that the center of gravity is brought much nearer the ground and the machine will almost never nose over when an obstruction is encountered in landing. If anything happens, the undercarriage is torn off and the machine slides along on its belly without a shock. If the landing gear of a high-wing machine is torn off, there are only the relatively light lower longitudinals and the cabin floor between the occupants' feet and whatever obstructions there may be on the ground, and there is every possibility of injury to the passengers' feet and legs. With the low-wing machine, on the other hand, the heaviest and strongest part of the whole machine is between the passengers and the ground. The value of this is borne out by 7 years of experience, during which no one was injured in accidents of the type described. In one case a low-wing monoplane, fully loaded, made a forced landing and came to rest on the bumper at the end of a railroad track. As might be expected, the whole bottom was torn out of the machine, but no one was in the least injured. If a high-wing monoplane, with the passengers sitting well down in the fuselage, had made this landing, the cabin would have been gutted, with results to the passengers that can be imagined.

Comfortable Seats Demanded

A. H. G. FOKKER[9]:—Although I am building high-wing monoplanes, I absolutely agree with Mr. Scherer that visibility has very little influence, and there is always an angle at which the ground is visible. Passengers stand in line for an airplane regardless of its looks. It counts far more if they get a ride for $2.50 instead of for $5.00. In fact, people will not care so much to look at the ground in the future. It usually cannot be seen to advantage from a high altitude, and low flying will be against the Government regulations. It is much better to provide comfortable seats where the passenger can rest his head than to worry about the windows. It is true that the high-wing monoplane is more likely to nose over when brakes are applied or a sand hole is encountered. The load must be arranged with that in view, and then it is just as safe or perhaps safer. Also, the repairs on the high-wing monoplane, in case of an accident, are usually far less expensive.

As to the question of monoplane or biplane or triplane, I have no prejudice because I have built every type, including low-wing monoplanes, high-wing monoplanes, triplanes, and even a machine with five planes. I flew that once and then discarded it because it was too unstable. But I have found that there are certain reasons for building a biplane or a triplane. At a certain time during the war it was necessary to get high altitude and high maneuverability. That was why I built a triplane. On the first triplane I built I had an

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[8] M.S.A.E.—Chief engineer, Junkers Corporation of America, New York City.

[9] M.S.A.E.—President, Fokker Aircraft Corporation, New York City.

interesting experience with the cantilever wings, which had a cantilever distance of only 6 ft. The wings looked so small that I was unable to sell the airplane. The officers simply would not fly an airplane with three little projecting wings. Although I proved to them with a sand-load test that in every case it was strong enough because of the short span and the deep spar, they would not get into it. So, to satisfy them, I built struts, with a section as thin and as long as possible, to connect the outer ends of the three wings. From that moment I had no trouble in getting the officers to fly with the cantilever wings; they saw the struts, and were satisfied. The triplane is desirable in war because a safe landing can be made with two planes if one is shot away. According to a recent story in *Liberty*, a German triplane lost its upper wing and came down safely.

Where the Biplane Excels

For pursuit planes, the biplane type is superior to the monoplane type. It is much easier to build a biplane with that tremendously high factor of safety that the Army requires, but the most important point is that a biplane, on account of its shorter span, is always more maneuverable, and maneuverability is the first consideration in a pursuit plane. It is difficult to build a monoplane with sufficient wing-area and a small span and to locate the wing so that it will allow good vision to the aviator.

In considering the weight of a monoplane, I am not prejudiced against metal but am willing to build metal wings if I see they are better. While I was developing my monoplane I offered to Adolph Rohrbach, who had had much experience with monoplanes and with metal construction, the chance to make metal wings for it if he could make them of the same size and weight as my wooden wings. After much figuring, he did not wish to accept the contract because he could not guarantee at that time, and I think he could not do so now, to build a lighter cantilever monoplane wing with metal than with wood, with the same factor of safety.

It is hard to make a monoplane wing large without making it too heavy, but the lift is greater than we expect. Our wings are thick at the root and thin at the tip and we have all kinds of wing curves with an average result that is good.

If the builder of a racing boat should place the cylinders outside the hull to get direct cooling we would say that he knew nothing about engineering, but, in spite of all our consideration of economy and air-resistance, we place our cylinders out in the air. That is the simplest and cheapest way.

In the future there will be larger wings. If the engines are mounted inside them there will be problems with long shafts, gears, clutches, variable-pitch propellers and other mechanical parts rather than with the wings themselves. There is a great opportunity for engineers and engine builders to produce units that can be mounted inside the wings.

The Internally Braced Wing

Arthur Halsted[10]:—I wish to emphasize Mr. Hall's remarks to the effect that the important distinction of type is not between monoplanes and biplanes but between internally trussed airplanes and externally trussed airplanes; the internally trussed airplane being typified by the tapered-wing monoplane, and the truss structure with external members being typified by the biplane. This is a fundamental design distinction.

Both externally braced monoplanes and biplanes have been with us since almost the beginning of aviation. The internally trussed airplane wing is a comparatively recent accomplishment. Probably the most important direction in which the design of any present-day airplane differs from that of the first successful flying machines is in the use of internally trussed wings of very high camber, tapered in plan and section on monoplanes.

The internally braced wing is in the infancy of its development, compared with wing structures having external members whose structural design was borrowed from experience in civil engineering. The internally trussed wing could be attained only after overcoming wing flutter, which was so discouraging to early attempts. This was accomplished by learning how to use thin wing-skins of metal or veneer as structural members, for which a precedent in civil engineering did not exist, and after experiments with thick-wing sections, aerodynamical design data for which is still all but lacking for wings tapered in both plan and section.

The success accomplished in so short a time by the internally braced monoplane, with wings tapered in plan and section, are extraordinary when compared with the long and less complicated research in the development of airplanes having thin wing-sections.

C. H. Chatfield:—I am glad to have Mr. Hall's correction as to the relative weight-allowance. He compared the braced monoplane with the single-bay biplane, while I had in mind rather the unbraced monoplane and the single-bay biplane, but I think, nevertheless, that I stand corrected on that point.

On the question of the view for the passengers, I am inclined to agree with Mr. Fokker rather than with Mr. Lee. The passengers will ride where they can ride most cheaply, and those who ride very much will not be particularly interested in looking out of the window. I rode on some European airlines this summer and noticed that the more hardened travelers were busy doing other things, very likely sleeping, and the view did not interest them very much.

I was glad to have Mr. Sikorsky's statement of his experience that the difference in performance of the two types is not very pronounced. That is probably a fair and reliable general conclusion.

I cannot entirely agree with Mr. Halsted that the distinction between internally braced airplanes and externally braced airplanes is a fundamental one. From considerations of structure the difference is one of degree and relates to depth of truss; and from the aerodynamic point of view the fundamental distinction still is between the monoplane and the biplane. I am glad, however, to have Mr. Halsted emphasize the importance of the recent development of unbraced monoplanes.

Harlan D. Fowler[11]:—The tendency in monoplane design has been to raise the stalling speed or to increase the wing loading so as to reduce the size of the wings. From the point of view of safety in case of a dead engine, the ability to recover quickly in a dive is greatly decreased. If the stalling speed is low, the length of dive required to recover will be correspondingly short and this may prevent many fatal accidents. Some restriction in stalling speed should be encouraged. A solution can be had in the high-lift wing that is possible of change while in flight.

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[11] M.S.A.E.—Engineer, Industrial Motors Corporation of New Jersey, Long Island City, N. Y.

Correlating Test-Data on Heat-Treated Chromium-Vanadium Steels

By E. J. Janitzky[1]

Production Meeting Paper *Illustrated with* Charts

An outline is given of the work performed and the method of procedure followed in correlating test results on specimens of heat-treated S.A.E. chromium-vanadium steel 6130 as a basis for revision of the physical-property charts for certain automotive steels. Revision of the charts was proposed by the Iron and Steel Division of the Standards Committee of the Society, and a subcommittee, of which the author is a member, was appointed to carry on the preliminary work of revision. The paper is a report of the results of the tests made.

Test specimens of S.A.E. Steel 6130, to be drawn at three different temperatures after quenching, were prepared by four steel manufacturers. These were distributed among 30 cooperating laboratories, which made a series of about 115 tests including complete chemical analysis, tensile-strength, and Brinell, scleroscope and Rockwell hardness tests on the specimens.

Results of the tests are given in frequency or probability curves, rather than in straight-line curves of averages alone, since the latter are regarded as an unsatisfactory method of expressing the results of such an investigation because of the variables. It was necessary to express the results so as to indicate a range, limited by minimum and maximum values, within which users of the charts might be expected to obtain satisfactory results.

The frequency curves show that the test specimens had a 12-point carbon-range, which approaches closely the S.A.E. specification. They also show a range in tensile-strength of about 34,000, 27,000 and 24,000 lb. per sq. in. for draws at 800, 1000 and 1200 deg. fahr., respectively.

Revision of the physical-property charts for certain of the automotive steels has been proposed by the Iron and Steel Division of the Standards Committee of the Society. A subcommittee, consisting of J. D. Cutter, Chairman; H. J. Chandler and E. J. Janitzky, was appointed to carry on the preliminary work of revision.

From a series of about 115 individual tests for each drawing-temperature, conducted by 30 operating laboratories, it was desired to prepare a physical-property chart for chromium-vanadium steel, known as S.A.E. Steel 6130.

Individual tests by each laboratory were to include the complete chemical analysis of 4 out of 12 1-in. round test-blanks. All 12 test blanks were then to be heat-treated, machined to the standard 0.505-in.-diameter tensile-bar and subjected to tensile-strength and Brinell, scleroscope and Rockwell hardness tests.

The tests were made on steels furnished by four different steel manufacturers, each of whom rolled his sample steels into 1-in. rounds before shipping them to J. M. Watson, of the Hupp Motor Car Corporation, for distribution among the various investigators. Each investigator received 12 specimens, marked as follows:

A-1	*B*-1	*C*-1	*D*-1
A-2	*B*-2	*C*-2	*D*-2
A-3	*B*-3	*C*-3	*D*-3

The letters served to distinguish between the manufacturers of the steel, and the numerals signified the temperatures at which the steel was to be drawn after quenching.

Instructions Governing Conduct of Test

All investigators were given the following instructions governing the conduct of the tests to be made:

(1) Analyze bars *A*-1, *B*-1, *C*-1 and *D*-1 for
  Carbon
  Manganese
  Phosphorus
  Sulphur
  Silicon
  Chromium
  Vanadium

(2) Heat and quench all test bars as follows:
  (*a*) Heat to 1600 deg. fahr.
  (*b*) Hold for 15 min. at that temperature
  (*c*) Quench in water

(3) Draw as follows:
  (*a*) The four bars marked "1" at 800 deg. fahr.
  (*b*) The four bars marked "2" at 1000 deg. fahr.
  (*c*) The four bars marked "3" at 1200 deg. fahr.

(4) After drawing, cool the bars in air

(5) Grind a flat surface on the side of all bars near the center of length and make Brinell, scleroscope and Rockwell tests

(6) Machine to standard 0.505-in.-diameter tensile-test bars, threaded ends preferred but not essential

(7) Make standard tensile-tests determining
  (*a*) Yield point (drop of beam)
  (*b*) Ultimate strength
  (*c*) Per cent elongation in 2 in.
  (*d*) Per cent reduction of area

(8) With your report of results submit the following information:
  (*a*) Type of tensile machine used
  (*b*) Speed of tensile machine
  (*c*) Sketch of test piece employed

The findings of the 30 laboratories were submitted to me, as the Subcommittee had appointed me to scrutinize them and carry out the construction of the diagrams. A perusal of the data supplied showed the results ob-

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tained by some of the investigators to be far removed from the apparent average of the others. It was decided, therefore, that the omission of these obviously erroneous figures would give more reliable results in the final curves.

Results Expressed in Frequency Curves

Single-line curves, as expressed by averages alone, were regarded as an unsatisfactory method of expressing the results of an investigation of this kind, due to the variables entering into the chemistry, heat-treatment and testing. The results must be expressed in such a way as to make possible the indication of a range, limited by certain maximum and minimum values, within which future users of the charts might be expected to obtain satisfactory results.

To determine these limiting values, the method adopted was the construction of frequency or probability curves. Stated simply, these curves are derived from application of the mathematics of probability to accumulated experimental data. The method has been borrowed from the biological and sociological sciences, and may be applied to any science in which the data collected are influenced by a high degree of variability. In these sciences the well-known straight-line curve to express results of experimental data is not applicable, as the information given by it is erroneous. Practical information can be obtained, however, by proper application of the probability curve. In most cases, where insufficient data are at hand, the probability curves will be jagged, but when sufficient data are available, they tend to become smooth, and the greater the abundance of data is, the smoother will be the curves. Therefore, mathematical expressions representing these curves can be developed. These expressions, it is believed, take a general form of

$$F = \frac{M}{\left[\left(\frac{M}{m} - 1 \right) \times \left(\frac{p}{P} \right)^{n} \right] + 1} \qquad (1)$$

where

F=Frequency sought
M=Maximum frequency
m=Frequency at any other point
P=Physical property corresponding to m
p=Physical property corresponding to F

To find n it is necessary to know three points on the curve. By selecting from the data the three points thought to have the most reliable values, determining n, and then developing the curves represented by equation (1), the results obtained will have the same degree

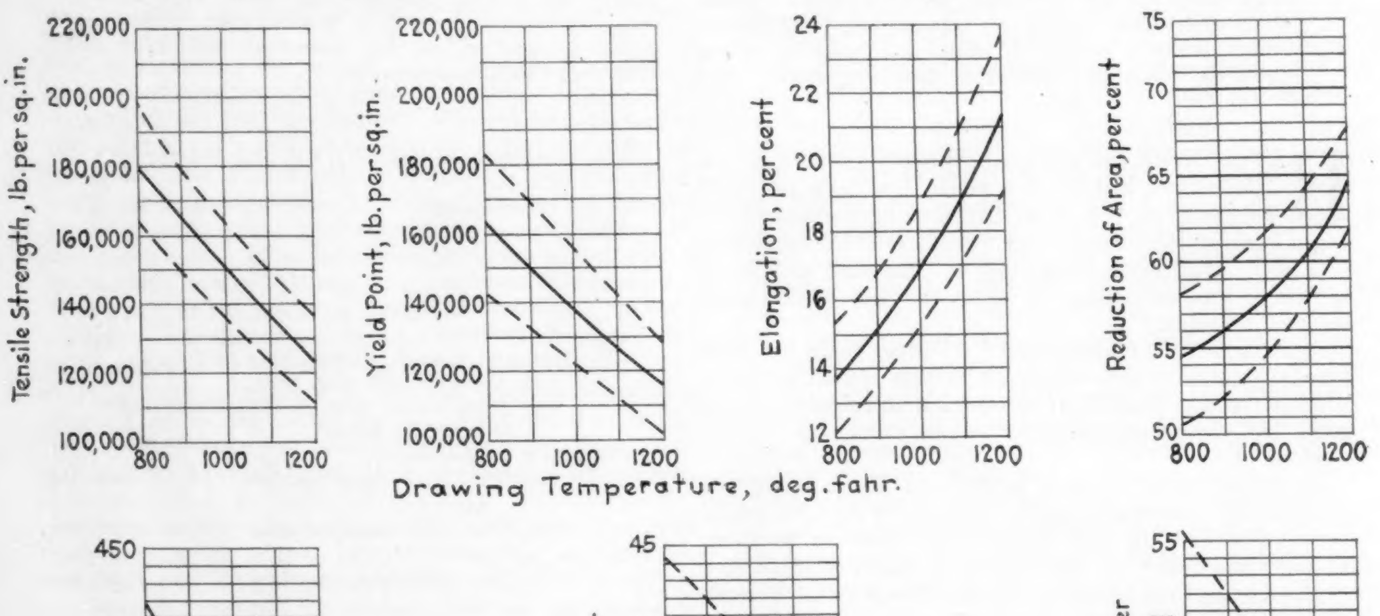

Fig. 1—Summary of Physical Properties of S.A.E. Chromium-Vanadium Steel 6130

Maximum and Minimum Values Are Represented by the Dash-Line Curves, and Averages of the Tests of the Specimens Are Represented by Solid-Line Curves. These Values, as Abscissas, Were Plotted against the Frequency of Occurrence of Each Value as Ordinates, and the Frequencies Were Plotted against the Drawing Temperatures, as in Figs. 2 and 3

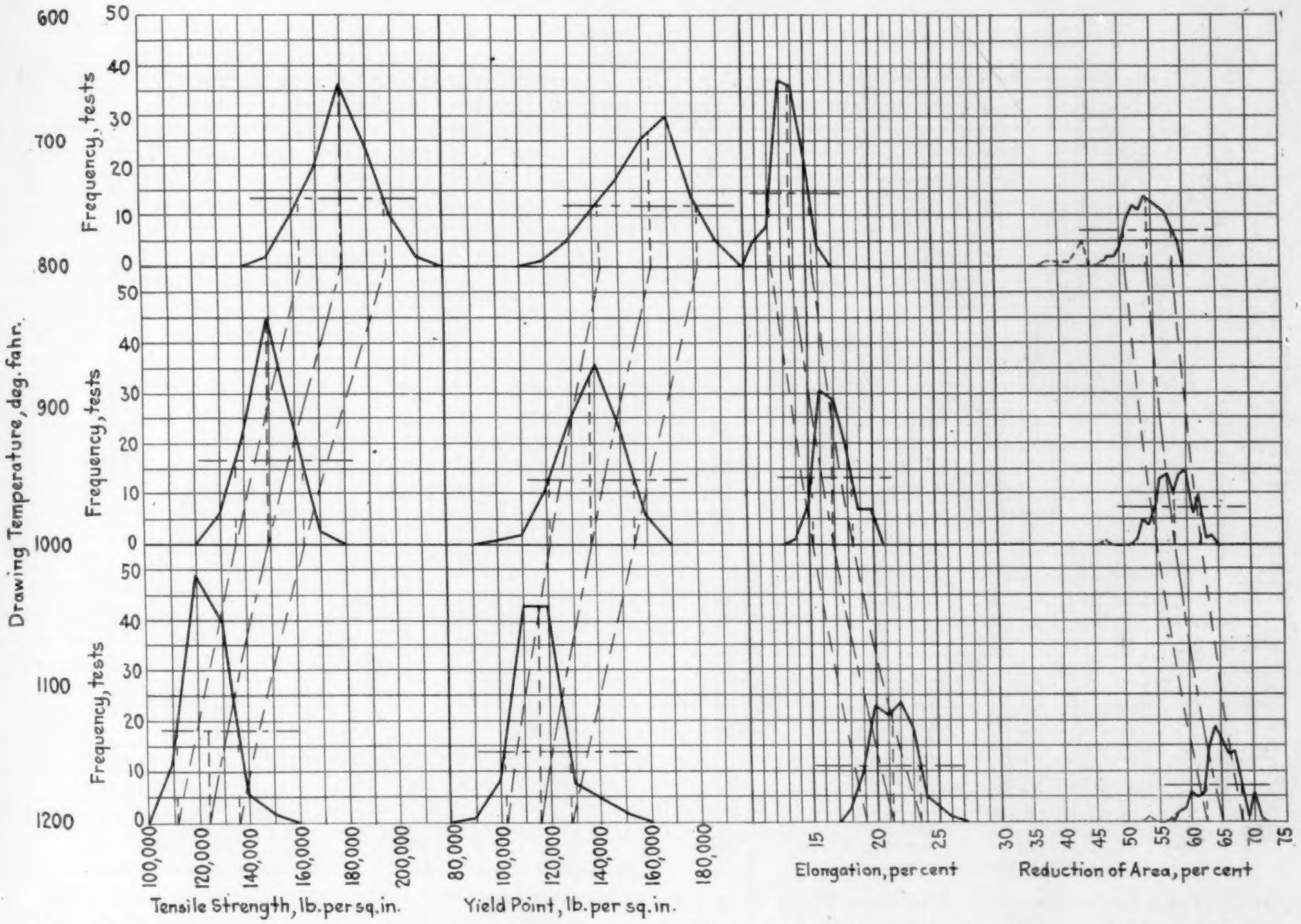

FIG. 2—FREQUENCY CURVES OF TENSILE PROPERTIES OF S.A.E. STEEL 6130 DRAWN AT 800, 1000 AND 1200 DEG. FAHR.

of accuracy as have the original values selected from the data.

METHOD OF CONSTRUCTING THE CURVES

In the case at hand, the values in Fig. 1 obtained for tensile-strength, yield-point, elongation, reduction of area, and Brinell, Rockwell and scleroscope hardness as abscissas, were plotted against the frequency of occurrence of each value as ordinates. The scale of the divisions on the abscissa must be determined by the number of tests to be dealt with, so that a sufficient number of frequencies can be obtained for each value used. The greater the volume of data available is, the smaller may be the value given to the divisions. The limiting values in each case were found by the following procedure:

Divide the planimetric area under the curve by the length of the base on which the curve rests, which length must be expressed in the same units as the area. This quotient gives the height of a rectangle constructed on the same base and having the same area as that enclosed under the curve. Construct this rectangle, and where the upper side cuts the original curve will be the maximum and minimum values sought.

Next, having maximum, minimum and average values for tensile-strength, yield-point, elongation, reduction of area, and Brinell, Rockwell and scleroscope hardness, the average values being actual and checking to within 1 per cent with the averages found by constructing the center of gravity by means of triangles, these maximum, minimum and average values were plotted against the drawing temperatures of 800, 1000 and 1200 deg. fahr. These curves are all shown in the accompanying charts, Figs. 2 and 3, as are also the probability curves for the chemical analysis of the specimens, Fig. 4.

As for the suitability of the method resorted to for the determination of maximum and minimum values, the following facts may be noted: The averages of the maxima and minima thus found check almost exactly with the actual mathematical averages, and also check with the averages found by the use of the triangular method applied to the frequency curves. Also, the ranges for the chemical analyses, as determined by this method, check very closely with the S.A.E. specifications for the steel in question. Since the method is as applicable to the chemical analysis as to both the averages and ranges, and as the averages of the properties check so closely with the actual averages, it is no more than reasonable to expect that a physical-property range or "specification" could be expressed by means of the maximum or minimum values.

STUDY OF THE INDIVIDUAL STEELS

Up to this point, the frequency curves applied to all results collectively. Much information will also be gleaned by a study of similar curves representing the individual steels *A*, *B*, *C* and *D* manufactured by the four companies. The frequency curves for the elements and properties were drawn and arranged in groups representing the several manufacturers, as in Fig. 5. The averages of the results from specimens supplied by each

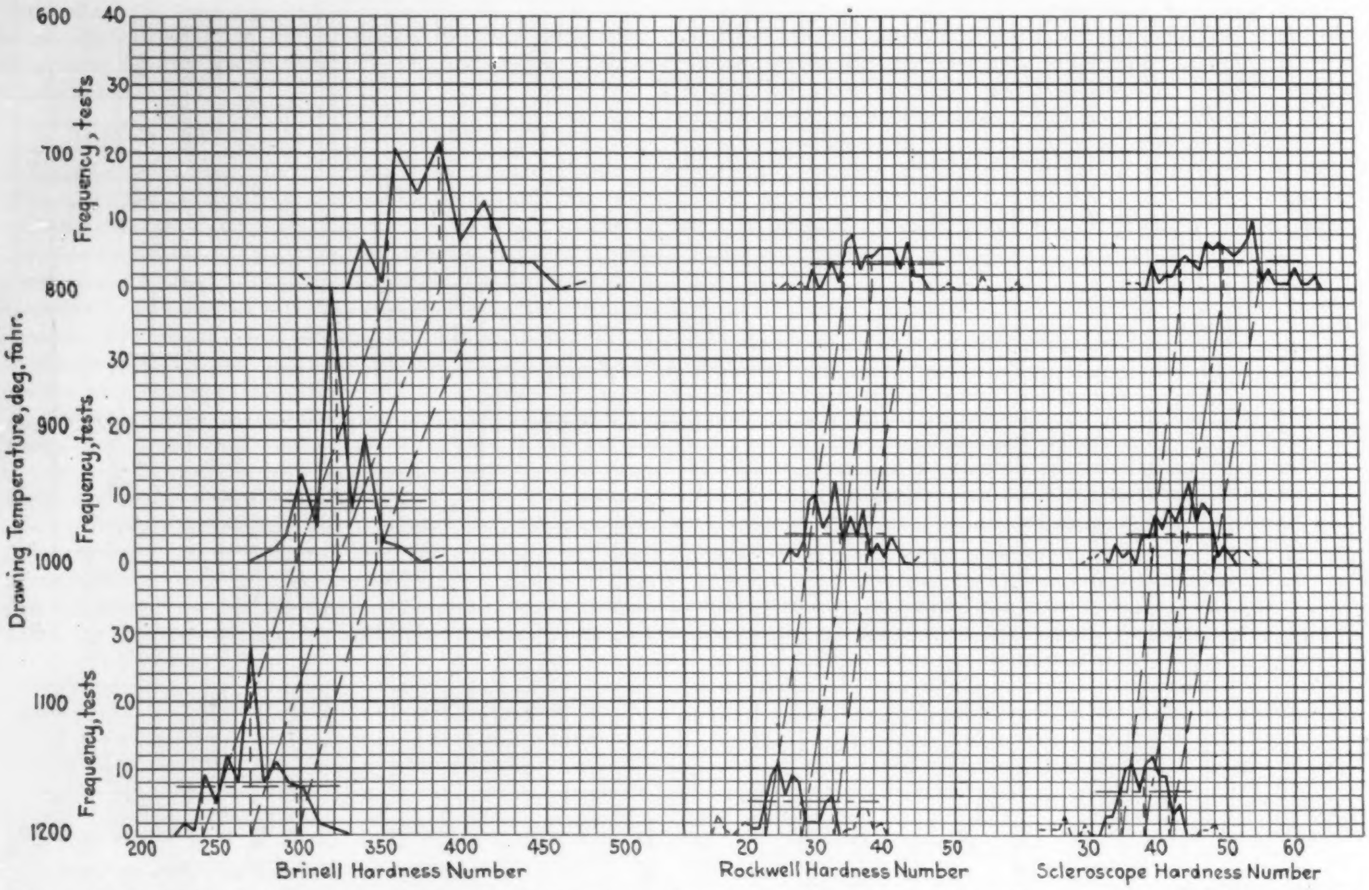

FIG. 3—FREQUENCY CURVES OF HARDNESS TESTS OF S.A.E. STEEL 6130 DRAWN AT 800, 1000 AND 1200 DEG. FAHR.

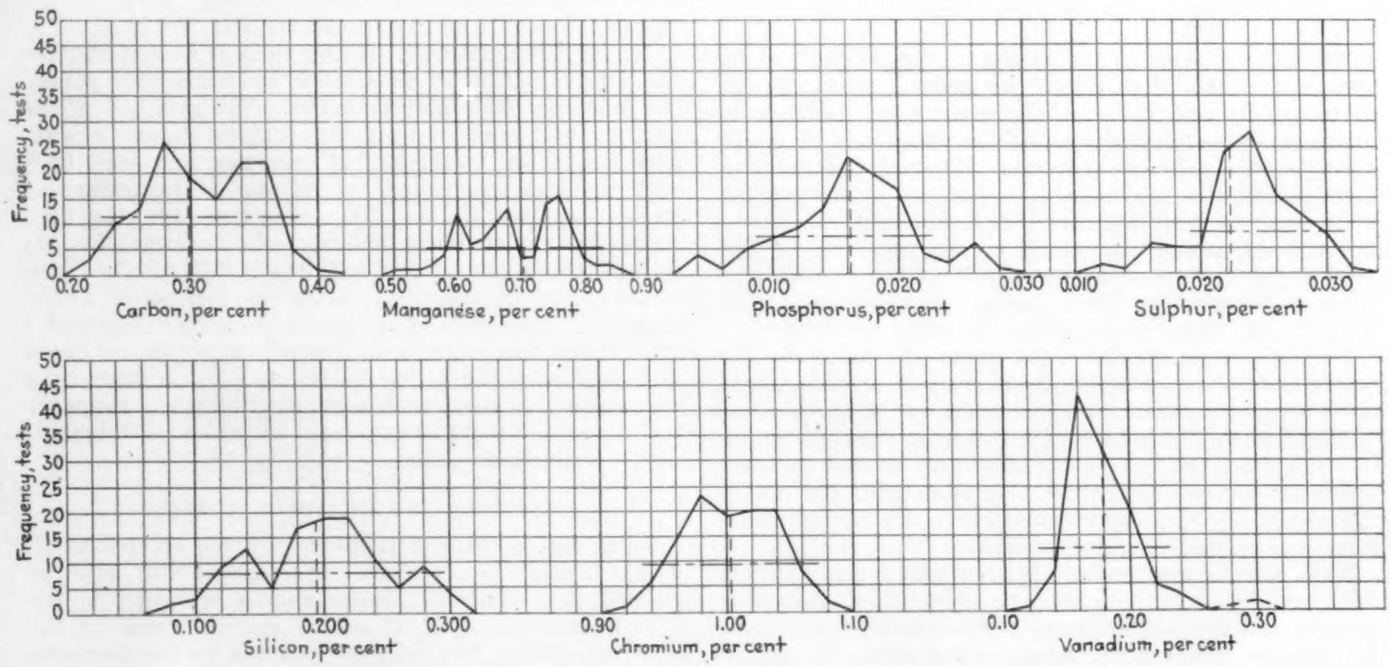

FIG. 4—FREQUENCY CURVES OF CHEMICAL ANALYSES OF S.A.E. STEEL 6130

company were then joined to one another to give what may be called "individual-steel-average" curves. These curves have been drawn only for carbon, manganese, phosphorus, silicon, chromium, and vanadium, and for tensile-strength, Brinell hardness and elongation after a draw of 1000 deg. fahr. The variations in the phosphorus, chromium, and vanadium content and in elongation are very slight and will not be considered in the discussion.

These curves show that two of the steels, *A* and *C*, have carbon averages on the high side of the specification, while one, *B*, is on the low side, and the remaining one, *D*, is in the middle. Correspondingly, steels *A* and *C* have a high tensile-strength and Brinell hardness, *B* has a low tensile-strength and Brinell hardness and *D* has values in the middle of the range determined by the maxima and minima. Regarding the manganese, steel *A* is slightly on the low side, steels *B* and *C* are well on the high side, and steel *D* is slightly on the high side of the specification. These considerations point strikingly to the domination of carbon over the other elements. The tensile-strength and Brinell-hardness curves are influenced markedly by the carbon content, the curves for these properties assuming the shape of the carbon curves, notwithstanding the fact that, whereas the individual carbon-averages range only from 0.27 to 0.33 per cent carbon, the manganese averages have a considerably wider range of from 0.61 to 0.75 per cent manganese, and the chromium, though the range is small, opposes the effect of the carbon, the steels with the higher carbon-content having lower chromium-content and vice versa.

Conclusions

From the frequency curves it is apparent that a 12-point carbon-range has been dealt with, which approaches very closely to the 10-point range allowed by the S.A.E. specifications. The curves also show a range in tensile-strength of about 34,000 lb. per sq. in. for a draw of 800 deg. fahr.; of 27,000 lb. per sq. in. for a draw of 1000 deg. fahr.; and 24,000 lb. per sq. in. for a draw of 1200 deg. fahr. The minimum values, which define the low side of the range, should be the values approached when the carbon is on the low side of the specification, and the maximum values should be approached when the carbon is on the high side.

This paper should be a guide for revising the physical-property charts so that they may be of more value to the engineer and the heat-treater, as present charts, which give no range, too often lead to controversies, and account for the variation in chemical composition, discrepancies in heat-treatment, and errors in testing.

THE DISCUSSION

CHAIRMAN FRANK P. GILLIGAN[2]:—It is believed that the charts presented by Mr. Janitzky will be of utmost aid to the engineer in determining the variations reasonably to be expected in steels within the same specification range.

JOHN D. CUTTER[3]:—The Subcommittee of the Iron and Steel Division is considering the advisability of developing charts, by the use of these probability curves, which will be more useful to the average engineer, purchasing agent, or inspector in the automotive industry. The physical-property charts now in the S.A.E. HAND-

[2] M.S.A.E.—Secretary and treasurer, Henry Souther Engineering Corporation, Hartford, Conn.

[3] M.S.A.E.—Sales manager, Fafnir Bearing Co., New Britain, Conn.

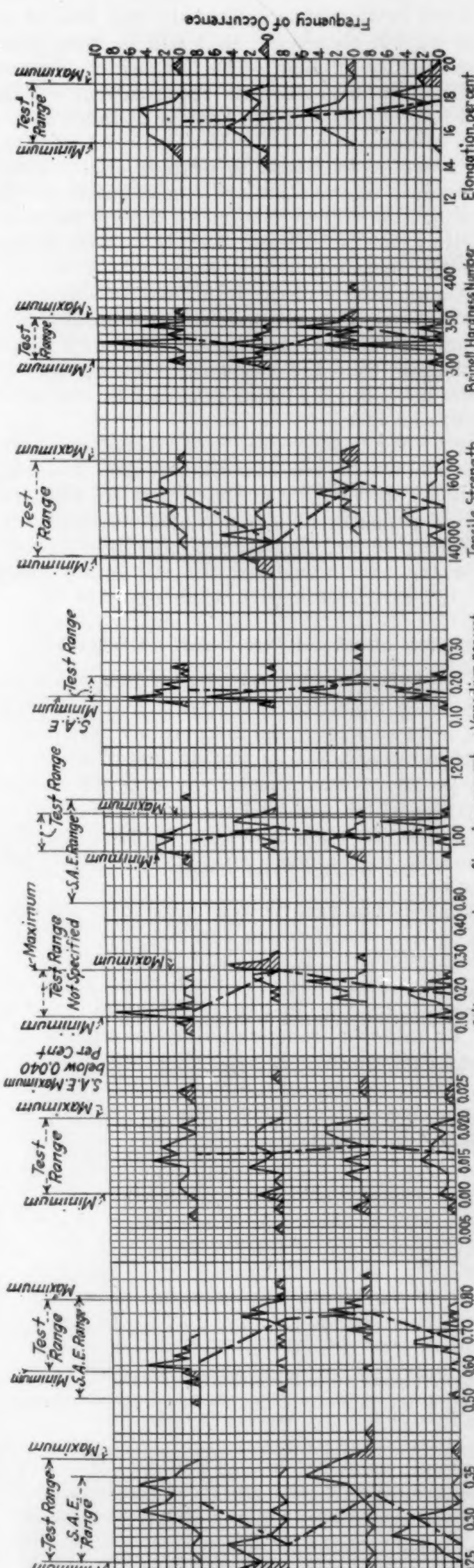

FIG. 5—FREQUENCY CURVES OF RESULTS OF CHEMICAL ANALYSES AND PHYSICAL-PROPERTY TESTS ARRANGED ACCORDING TO MANUFACTURERS OF TEST SPECIMENS

Specimens Were Quenched from 1600 Deg. Fahr. in Water and Drawn at 1000 Deg. Fahr. Shaded Areas Indicate Tests that Were Outside of the Minima and Maxima, Which Are Indicated by the Light Vertical Lines. The Heavy Dash-Dot Vertical Lines Indicate Averages

BOOK have been criticized considerably and this is an attempt to bring out something that will be more practical and more easily applied. The purpose of presenting this method is to ascertain the reaction of the industry and the members of the Society at large on the use of curves so developed.

It will be a stupendous task to develop charts along these lines for each of the standard steels, but it will be well worthwhile if it will help to make the curves more useful than they are at present and if it will be appreciated by the members.

I think the maximum and the minimum, as developed by Mr. Janitzky, will give a much more comprehensive picture of what can be expected from a steel of a given S.A.E. Specification than the average curves we have in the HANDBOOK now, but I should like to find out what others think of the idea.

C. N. DAWE[4]:—We have worked on this matter in the Subcommittee on which are Mr. Cutter, Mr. Janitzky and Mr. Chandler, and I feel, as the others do, that the present physical-property charts are open to criticism. I was much pleased to find that curves have been worked out by taking the maximum and the minimum. The subject is highly mathematical in some respects.

THE METHOD MORE SIMPLE THAN IT SEEMS

CHAIRMAN GILLIGAN:—I am inclined to disagree with Mr. Dawe's remark that this is a highly mathematical method. So far as I can see, the method has vast possibilities to enable anyone who is testing materials to go into the records and to plot these tests and automatically exclude those which are without a given specification range. It should open the files of many of the automobile testing laboratories so that we could use their test results.

E. J. JANITZKY:—The results were arrived at simply. For instance, in the specification for S.A.E. Steel No. 1015, the carbon minimum is 0.10 and the maximum is 0.20 per cent. Dividing their sum by 2 gives the average as 0.15 per cent. Or, in general, we may take a minimum of m, add the corresponding maximum M, divide by 2 and find the average A. Any actual maximum and minimum values, once found, may be substituted for m and M. The problem now is to find the maximum and minimum.

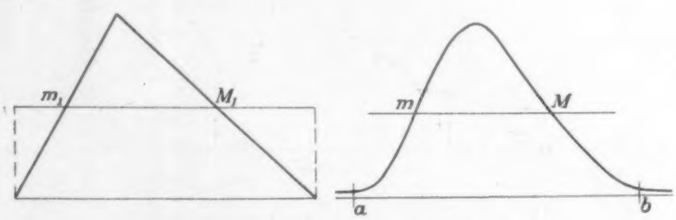

FIG. 6—AVERAGING A FREQUENCY CURVE
Diagrams Illustrating the Finding of the Maximum and Minimum Points from Which the Average Is Obtained

Assume a triangle as at the left in Fig. 6: Dividing the area of this triangle by its base gives the height of a rectangle having the same area and the same base as the triangle. If this rectangle is constructed on the same base as the triangle, the intersections m_1 and M_1 of the upper side of the rectangle with the sides of the triangle are the maximum and minimum values, and the average of the maximum and minimum is the actual average.

The same simple principle is applicable to the case when a curve is considered instead of a triangle. The area under the curve is found easily with a planimeter. The point to consider now is: What determines the length of the base on which the curve is to be considered as resting? Obviously, the curve must be discontinued at certain points, such as a and b, in the diagram at the right in Fig. 6, beyond which points any values that occur may be regarded as freaks. The only rule that can be given for the determination of the location of these points is to use good judgment.

A. B. KINZEL[5]:—How do you determine where to cut off the end of the frequency curve? The greater the number of specimens you have, the wider the base range will be, and the wider will be the zero frequency.

ARBITRARY JUDGMENTS ARE REQUIRED

MR. JANITZKY:—We simply cut it off arbitrarily. If someone gets a result that is widely at variance with the others, we know that the test was a failure because of friction or some other error. For instance, in the upper central curve of Fig. 3, the curve runs on to the right in a ragged way. We cut that off entirely. It is necessary to take some such liberties.

MR. KINZEL:—We have used this method very successfully in determining the strengths obtained on welds with various welding rods in which our company is interested. We kept a record for many years, but did not know what value to take in comparing the strengths. In making application of the probability curves, we used the same method that Mr. Janitzky has used. This made it possible to get satisfactory values which have been borne out in practice. The method is certainly one that can be recommended most highly.

FREQUENCY CURVES ARE USED IN OTHER WORK

JOHN YOUNGER[6]:—I am glad to see the Society take up the work of obtaining more scientific averages for its steel specifications. The method of plotting normal distribution curves, or curves of variables, does get a more scientific average. For those interested in the subject I would recommend a small book called Primer of Statistics, written by W. P. Elderton, in which many variable curves are given. Some deal with the distribution of sizes of leaves, others with the sizes of men at a given age, others with the dimensions of nuts and shells. Curiously enough, the curves are all similar. A series of such curves could well be worked out for the variables resulting from steel treating.

MR. KINZEL:—In the non-symmetrical curves the top of the curve is the probable value, but it is not the average value. That must be taken into consideration. Mr. Janitzky's method takes care of that in a new and excellent way.

CHAIRMAN GILLIGAN:—The essential point is that we want to prove that the present S.A.E. physical-property curves can be improved. This is the method proposed. To make it effective we must have adequate data, such as have been accumulating for years. Ultimately it should be possible to send standardized cross-section paper to our automotive metallurgists and let them plot their results thereon and turn these charts over to the Subcommittee to do the heavy labor.

E. W. UPHAM[7]:—It seems to me that a great many

[4] M.S.A.E.—Manager of automotive division, Vanadium Corporation of America, Detroit.

[5] Union Carbide Co. research laboratory, Long Island City, N. Y.

[6] M.S.A.E.—President and editor, *Automotive Abstracts*, Columbus, Ohio.

[7] M.S.A.E.—Chief metallurgist, Chrysler Corporation, Highland Park, Mich.

variables are brought into play. The test-specimens described in the paper were sent out to 30 laboratories, and that means 30 different heat-treating departments and methods. Were any instructions given, when sending out the specimens, as to the length of time of the heat-treating, especially the draw heat?

MR. JANITZKY:—No, we wanted actual results that will be duplicated in the plants, not under laboratory conditions. No matter how carefully we work, there always will be a maximum and a minimum; nature works like that. Insurance companies are able to tell how much money they must have on hand every month for deaths and accidents, by application of the law of averages.

DATA FROM THE INDUSTRY ARE NEEDED

CHAIRMAN GILLIGAN:—The size of the test-specimens was standardized by the Subcommittee, but the present S.A.E. charts are supposed to be representative for sections up to 1½-in. diameter or thickness. What we are getting is general information, and we are working to make it more intelligible and safer than at the present time. As regards the extremes brought out in the present series of tests, it should be borne in mind that this is the second attempt of this kind. Two or three years ago a similar attempt was made, and when the results were scanned we began to wonder what kind of heat-treatment was going on in this Country. There was a 100-per cent variation in the results in the different laboratories, although the laboratories selected were supposed to be the best in the industry. What we wanted this time was a reflection of current practice, and these variations give it.

The figures we want to give to the purchasing agent, the engineer, the designer, and the steel treater, are safe average figures with a variation that may be legitimately expected from plant to plant and from steel to steel. I think this method will give such figures. To make this plan effective we must have data; and those data are in the files of the automotive industry. This is primarily a proposition for the men in this industry.

J. H. HUNT[8]:—I understand that you are trying to show not only the average results which a steel can show but also what the variations are. If I may mention an incident that came to my attention some years ago without being unduly facetious, I am reminded of an engineer who was called upon to design a bridge to go over a certain stream. He measured the height of the masts of the ships that used the stream and found the average of the heights. He took this average to obtain the clearance for the bridge. I have always had a suspicion that something was wrong with that bridge.

What is the designer to do with the proposed charts? It seems to me he must take the minimum, not the average or the maximum. To be safe, if he takes the average, he must add, consciously or unconsciously, another little factor of ignorance or uncertainty to what we call the factor of safety. Will someone explain why these charts, when they are finished, will be better for the designer than the charts we already have? Do the present charts give averages that are too high, or what is the difficulty?

CHAIRMAN GILLIGAN:—The present physical-property charts represent the minimum values for carbon percentage, for tensile-strength, yield point, reduction of area and elongation, which, of course, could not all occur on any one steel.

There are two angles to consider when we refer to the designer. The alert progressive company does not depend upon the HANDBOOK for all its information on materials and design. Nevertheless, a moral obligation rests upon us because we have brought out steel-specification and certain physical-property charts which have been incorporated in the HANDBOOK. These charts are conservative. In some instances the engineer should be able to figure on a little better value than is contained in the present charts. The second line on the chart will apprise him of this. In other cases, for example in the chromium and vanadium steels, we could not produce a chart of the present form that was reliable because the physical-property variations were so wide, due to the carbon, manganese and chromium ranges, that the members of the committee could not decide upon any particular curve. We came to this proposed method because we never have had a satisfactory method for clearly depicting the physical properties of chromium-vanadium steels in the S.A.E. Specifications.

If we hold to a 7-point carbon range, instead of the 10-point range of the charts in the HANDBOOK, we can approach the practical curve in some of the steels. When we get into the higher alloys, a 10-point carbon range is wide for the present method of depicting physical properties. Assuming that the present method is discarded and the new method is substituted, a band will appear on the chart instead of a line. Therefore, the engineer who has no metallurgical department to draw upon for data is forewarned that the desired physical properties, the resistance to fatigue, and the like, are not definite fixed values but are variable within a certain range. He is warned to secure more specific information on the steel with which he is dealing. These physical-property charts cover steel to a common analysis but not to a common quality.

A man who is following closely the purchasing, inspecting and testing of steel develops his own physical-property charts, or he should do so. The proposed charts will show clearly the physical properties inherent in material bought from various steel suppliers. Some metallurgists can show data on the physical properties of steel that has been bought from various steel companies for 10 years or more, which reveal why some producers' steels are actually worth more than others' steels.

The proposed method is not perfect but it is one step further in educating the steel user and in getting nearer to the real physical-property variations of the material. The common analysis does not give standard physical properties after heat-treatment. In our S.A.E. Steel Specifications we have not standardized quality; that depends on the inspection practice of the purchaser.

SHOW EXPECTANCY IN COMMERCIAL PRACTICE

MR. KINZEL:—There is another angle that I think should be brought out. The designer, in general, does not use any figure in calculating his design except the ultimate tension limit. The other values are used to determine the additional factor of safety when employing a material. The designer uses them for selecting a material but not for carrying out the actual design. After dividing by the ultimate strength whatever safety factor is selected, he will have additional safety from the ductility characteristics of the material. The engineer

[8] M S.A.E.—Chevrolet Motor Co., Detroit.

looks at reduction of area, at elongation and at the ratio of yield to arrive at the latter safety factor. Now we are giving him something else in addition; namely, what he may expect of the steel when he actually gets it. That is, he may design on the average value but, if he knows that one of two steels will possibly show 20,000-lb. deviation on test and the other only 10,000-lb. deviation, other things being equal, he will choose the stronger steel. I think the minimum and maximum limits, as found by Mr. Janitzky, give real information to the designing engineer.

MR. CUTTER:—Is it not true that the difference between the present method of producing the physical-property charts in the HANDBOOK and this method is that the old curves represent a particular heat of steel within the analysis range as heat-treated and tested in a particular laboratory, whereas the new method will represent what may be expected of a steel from any reliable source of supply, heat-treated with average intelligence in any fairly well-equipped heat-treating plant and tested with average intelligence in any laboratory?

BASIS OF THE PRESENT CHARTS

CHAIRMAN GILLIGAN:—In drawing up the present physical-property charts, more than one heat of steel is represented. We had on the Subcommittee producers of what we call quality steels and producers of quantity steels. If only quality producers had been consulted, the charts might have shown somewhat higher limits. The present charts show general averages.

This proposed method gives a band or zone indicating the range of possibilities as they exist in industry today. With such a chart in the S.A.E. HANDBOOK, it would be possible for any laboratory testing materials conforming to S.A.E. Specifications to plot on the printed chart the values it was obtaining and to ascertain if certain steels gave values nearer the maxima than others. If the price were the same, they would have a guide; if the price were different, the advantages could be weighed against the greater cost. Such a chart would give the steel consumer more information about the variations that are inherent in the materials he is using, regarding which he is at present more or less ignorant.

UNCONTROLLED VARIABLES AFFECT RESULTS

H. T. CHANDLER[9]:—It is the purpose of the charts which accompany the steel specifications published in the S.A.E. HANDBOOK to show graphically the relation between the physical characteristics of the various steels specified and the drawing temperature to which they are subjected during heat-treatment. Such charts are desirable for the automotive engineer, inasmuch as they indicate the engineering characteristics which may be expected from the different standard steels and, in addition, serve as a guide to their proper heat-treatment for various kinds of service.

It would seem at first thought to be a comparatively simple matter to obtain the data required for the preparation of these charts, but a little consideration will indicate some of the difficulties to be surmounted. Any two-dimensional graph, such as we are dealing with, assumes a fixed set of conditions for all variables other than those under consideration. In the case of steel, we know that the physical properties, as determined from the behavior of test-bars in the tensile test, are subject to considerable differences from causes other than changes in drawing temperature. If we attempt, then, to set down any particular set of values of properties as representative of what may be expected from a specification, we can do so only by first standardizing these other conditions.

With respect to the mechanical variables of testing, method of heat-treating, size of test pieces, and the like, no particular trouble is experienced. All these factors may be conveniently set within limits which will result in no very great variation from commercial practice. The chief difficulty arises when we consider the effects of chemical composition and some of the more elusive variables having their origin in steel-making processes.

It is necessary, for obvious commercial reasons, to permit a certain latitude in the chemical composition of all steels. An individual chemical specification, therefore, does not define a single definite steel but rather a series of steels, all similar, it is true, but nevertheless different. Thus in a specification which covers a range of say 10 points in carbon, 20 points in manganese, and corresponding ranges in the other elements of composition, there can occur many combinations of different values of the respective elements, each combination defining a different steel and hence yielding different results in test after the same heat-treatment. The first problem, then, is to determine which one of these many steels, all of which fall within the specification limits of composition, we shall use as a representative of the entire group.

PRESENT CHARTS SERVE ONLY A LIMITED PURPOSE

For the metallurgist who is familiar with the effects of the different elements on the physical characteristics of steel, and is thereby capable of judging their quantitative influence under variable commercial conditions, either the *average* physical properties of the group or the physical properties of the steel of *average* analysis would be a satisfactory indication of what could be expected from the specification.

For the engineer, however, who must accept the charts at their face value, without allowances for differences arising in practice, *average* results are not sufficient. His interest is chiefly in knowing the least strength or toughness he is likely to encounter within the limits of specification. Accordingly, and since the S.A.E. Charts and Specifications are intended primarily to serve those having limited metallurgical experience, the procedure of the committee which prepared them has been to determine the *minimum* strength as indicated by elastic-limit and tensile-strength as well as the *minimum* toughness as expressed by elongation and reduction in area, within the limits of the specification, and plot these results as characteristics of the steel.

The charts so prepared have served a useful though limited purpose. As a means of indicating the least values of the various properties, *taken individually* and likely to be encountered under the specification, they are satisfactory. As a guide to the selection of the proper steel for a given requirement or as a description of the peculiarities and commercial usefulness of the various standard steels, they are open to serious criticism. It is a little as if we attempted to compare the merits of race horses by their poorest track performance, or the relative skill of two marksmen by their worst shots. One objection arises from the fact that,

[9] M.S.A.E.—Assistant to president, Vanadium Corporation of America, New York City. Mr. Chandler's discussion was submitted in writing subsequently to the meeting to explain the object of the revision of the charts, as proposed by him to the Iron and Steel Division.

while elongation and reduction in area vary directly with drawing temperature, i.e., they increase with an increase in temperature, the tensile-strength and elastic-limit correspondingly decrease. This inverse relation between the factors of toughness and the factors of strength also persists with most of the other variables influencing these engineering characteristics of steel. In other words, the conditions which arise to decrease strength also operate to increase toughness, and the converse also is true. The result is that only under a most extraordinary set of circumstances could minimum values in all these properties occur simultaneously. If, therefore, we plot as our data a set of conditions which seldom if ever occurs, the results, at best, will have a very limited application and may be seriously misleading.

New Method Meets Objections Satisfactorily

The method of revision which I suggested to the Iron and Steel Division, and some of the mathematical aspects of which are the subject of Mr. Janitzky's very fine paper, will satisfactorily meet this and some of the other objections which limit the usefulness of the present charts. It is by no means a new or untried procedure; it is the standard and accepted method of digesting data in all branches of accurate physical measurement and has been especially valuable in those sciences, such as astronomy and biology, in which the number of variables influencing the results is large and their action complicated. No great change in the form of the present charts is contemplated. Tensile-strength and elastic-limit will still be indicated in conservative minimums, for these are factors which enter directly into some of our engineering calculations. The chief difference lies in the method used in obtaining these data and in the establishment of a more accurate and useful relationship between strength and toughness.

Whereas previously the results were obtained from laboratory action and were therefore subject to many obvious limitations, the new data will represent the collective experience of actual use. The method follows the procedure prescribed by the mathematics of probability and is based upon the truth of the philosophy that we can predict what will happen in the future by what we have observed to have happened in the past, and the accuracy of this prediction is influenced by the numbers of our observations.

In the many years that the S.A.E. Standard Steels have been in existence, thousands of tests have been made and most of the data on these tests are more or less readily available. Properly interpreted, they can furnish us with a most accurate and valuable record of the physical properties we may confidently expect from our steels, commercially.

Mr. Younger:—The question of variation is common in designing and production engineering. Suppose the engineer wants a quantity of 2-in. shafts. He actually gets a few shafts that are 1.999 in., then greater numbers of the sizes nearer 2.000 in., and a few in decreasing numbers until a diameter of 2.001 in. is reached. The designing engineer is satisfied with the average of these. He does not say that the 1.999-in. shafts are too weak because his factor of safety does not allow for them. His factor of safety does allow for that 0.001-in. variation. He can do the same in the realm of steel treating. He can select an elastic limit and multiply it by some factor so that the variations will be within his factor of safety, and these limits would fall between the points that Mr. Janitzky has on his curve. It seems to me that the two ideas of tolerances in manufacturing and tolerances in heat-treating are quite analogous.

Will Develop Curves if Value Warrants

J. M. Watson[10]:—It can be seen from these charts that a great deal of work has been done to get them into their present condition. I think that the Iron and Steel Division is entirely willing to do much more work and spend more time in developing them if the curves will be of enough value to the industry at large to warrant it. Sometimes it is difficult to get much action on work of this kind. It is purely gratuitous work and always has to take a place secondary to production work in the various plants to which we send the test-specimens, but I feel sure that the Iron and Steel Division will go as far as the members want it to go in improving the charts so that we shall have a better idea of what the steels will do under various conditions.

Mr. Hunt:—I should like not to have my previous remarks misunderstood. On the basis of the explanation made I wish to endorse the work already done, and I hope it can be carried through. The chairman and others have pointed out the value to the designer and the production man of understanding what the variations are. This will help a great deal and ultimately will improve the product. I think the Committee is to be congratulated on having opened up this subject and carried it thus far.

Chairman Gilligan:—The Iron and Steel Division always has desired to retain the confidence of the individual member. It does a great deal of work that is not primarily for the automotive industry, but there are in existence S.A.E. Specifications and S.A.E. Steels that are used by many who do not have as much close metallurgical guidance as we sometimes feel they should have.

We hesitate to become too specific in the rules and instructions, because long-distance metallurgy is a rather dangerous practice. One of the functions of the Society is to ascertain facts, and we feel that by developing these charts we have secured a method of presenting more facts, lessening the factor of ignorance, so called, and, in the end, providing a means of measuring the quality factor of certain steels and of promoting improvement of quality. If this information is to be worth anything, it should be used by the engineer; if it will not be worth anything, we want to know that before we do the work.

Full Discussion of Plan Wanted

Mr. Hunt:—Would it not be a good plan to send a copy of this paper or a summary of it and of the discussion, including particularly the explanation the chairman has made, to chief engineers, to metallurgists, and perhaps to production managers and purchasing agents in the important companies, to see if we cannot get some support?

The assistance of a large number of laboratories is needed. These laboratories are already very busy. Possibly more cooperation can be obtained if other departments than the metallurgical department can be brought to understand the object it is desired to accomplish.

Chairman Gilligan:—That is one possibility. An-

[10] M.S.A.E.—Metallurgical engineer, Hupp Motor Car Corporation, Detroit.

other is to slate this whole discussion for a meeting such as the Annual Meeting, at which the designers and the engineers will be present in force.

MR. HUNT:—Your last suggestion probably would gain the attention of more people. A third suggestion is, if there are enough members on the Committee who are in such a position that it would not be too burdensome for any of them, to have some of them call at the various plants and explain it.

CHAIRMAN GILLIGAN:—We have two or three members of this Subcommittee in Detroit and the vicinity, and we can suggest it to them. We have other members in other localities who probably could make a more intensive campaign and search out any defects that may exist in the proposed method.

MR. CUTTER:—I think the Subcommittee would be willing to try a personal canvass. Would it not be possible also to schedule this subject for the Annual Meeting, as suggested, and to secure the presence of as many designers as possible, so as to have a full discussion and find out if it really is worthwhile to go through the tremendous amount of work?

CHAIRMAN GILLIGAN:—I think we can safely refer that suggestion to the Meetings Committee.

Supplemental Bonuses

THE supplemental bonus is an award in cash or its equivalent for the attainment of specific standards. It presupposes the payment of the regular wage or salary and is entirely separate and apart from the ordinary stipend. It is an earned award, not a gratuitous offer. In the case of wage earners, the standard to be met is something other than mere quantitative output. In the case of the supervisor and executive, the standard is one of excellence or merit in line of duty or of distinguished rating in special capacities.

The National Industrial Conference Board has prepared a study of types and scope of supplemental bonuses, together with some opinions concerning their effectiveness. The study covers the experiences of 141 companies employing a total of more than 500,000 workers, of which number 144,713 were participants in some form of supplemental-bonus scheme.

The supplemental bonus was devised for wage earners to create an interest on their part in more than mere quantitative output. The majority of plans in the companies investigated are designed primarily to secure a greater regularity of attendance. In an effort to reduce labor turnover, length of service has been made a determining factor in the award of the bonus in many companies. Other counts included in figuring the award for productive workers are: improved quality; prevention of waste; reduction of costs; prevention of accidents; shipments; and general merit.

The supplemental bonus is being used in numerous instances to obtain maximum cooperation from supervisory forces. In addition to the points on which awards are based for wage earners, salaried supervisors are rated on the following factors: increased production; maintenance of schedule; suggestions or improvements; arrangement and appearance of department; earnings of department; and departmental record of sales and manufacturing costs compared with investments.

The supplemental bonus for the executive is designed especially to provide an incentive to greater effort beyond the customary increase in salary, especially when the maximum salary has been attained. Frequently the results of special effort are not sufficiently tangible to be measured. In other cases the specific functions of the position may be such as to show the result of special application. Briefly stated, the bases for awarding the bonus are: general merit; savings between budgeted and actual expenditures; inventions and conspicuous service; increase in sales, in profits above quota, in output, in business; decrease in defective products and labor cost; general factors, such as operating ratio, distribution of securities, and satisfactory personnel relations.

With a balanced scheme of incentives for all classes of employes, an integral working unit should be established. The factors determining the bonus should be those which are definitely connected with the participant's immediate tasks and which interrelate with other departments. The plan should be simple and readily within the mental grasp of all who participate in it. The amount of the bonus should be a true reflection of the contribution of the employe receiving it. The plan should not be controlled by the same factors which determine the basic wage, and it should be kept entirely apart from the basic wage.

The plan must be fair and unbiased. It must create a mutual regard between employer and worker. It should offer a sufficient reward to stimulate enthusiasm. Insufficient reward may have a deleterious effect rather than a wholesome one. If the plan is entirely automatic, there will be little difficulty in allocating the bonus. If it is flexible, allowing for legitimate excuses, a wage earner should be on the committee of awards to assure the workers of a fair consideration of all cases and exceptions.

The attitude of the management need not be paternalistic, but it should be based on the idea that its interests and those of labor will be advanced by the payment of a sum supplementing the wage, which will have a stimulating effect on the employes of the company whether they be mechanics at the machines, the supervisors at the desks, or the executives in their offices.—*Law and Labor.*

The Large-Scale Operator's Influence on Design and Construction

By R. E. Plimpton[1] Chicago Section Paper

To solve fleet-operation problems successfully, a professional consciousness is needed among the supervisors and the engineers engaged in the operating field, awakened by analyzing and making known generally the methods and practices used by the operators of individual fleets of motor-vehicles, according to the author.

In developing his subject he asks the following questions and comments upon them: Has the operator any influence on design? Is that influence good or not? Whatever the influence is, can it be improved and made more effective? If it can be made more effective, how can this be done? If it cannot be made more effective, what is the reason?

Regardless of variations in duties and of conditions in organization, each large-scale operator is vitally concerned with matters of design and construction. This applies not only to the complete vehicle but also to wearing parts, such as tires, brake-lining, spark-plugs, fuels and lubricants, all bulking large in their effect on operating costs. The author calls attention to the difference between having vital concern about a subject and having influence on that subject. The first is more or less static; the second should mean a share in the progress of the art and a definite contribution to the better adaptation of motor-vehicles to their various tasks.

First reviewing the situation insofar as it relates to the standard design as developed and produced in the factory, there are two widely divergent opinions. The opinion of the operator indicates that he conducts a testing laboratory for the manufacturer and that the supervisors in the larger installations are acting as consulting engineers for the factory and its service department. Some operators even claim that they are forced to take over functions of the production end of the factory and to complete the vehicle before it can be put to work. Carried further, this opinion indicates that the operator alone is responsible for all improvements and that the factory engineering department, with all its facilities for designing and experimentation, is greatly influenced by the suggestions of the operator. At the other extreme is the view held by the factory engineer who may deny absolutely the value of ideas or suggestions for improvement that are made by the operator unless they can be investigated at first-hand and the surrounding and perhaps controlling conditions taken into consideration.

The use of a system in collecting two kinds of data is necessary if an operator is to pass reliable judgment on design and construction; that is, data with regard to cost of operation and maintenance as well as data with regard to defects.

Any definition of "large-scale operator of motor-vehicles" necessarily will be arbitrary but, for the present purpose, it is sufficient to say that an installation purchasing fuel in tank-car lots is of the large-scale or "fleet" variety. This method of classification was suggested by an engineer in charge of transportation for a petroleum refiner, and has the advantage of applying equally well to different types of service such as that of the truck, taxicab and motorcoach.

Making a number of what are believed to be fair assumptions, we find that the large-scale or "tank-car" operator would be responsible for 110 motor-trucks, 80 taxicabs or 40 motorcoaches. These might average 10,000, 25,000 and 50,000 miles each per year, respectively, and show a performance of 5, 9 and 7 miles per gal. of fuel for motor-truck, taxicab and motorcoach operation. These unit figures are high, if anything. A 50-truck fleet is rightly a large and important installation, and favorable discounts may be the privilege of the 10-truck owner in the purchase of parts and supplies.

The fuel requirements can be considered roughly proportional to the total operating-expenses, and thus fairly serve as a measure of the "influence" of the large-scale operator as just defined. Our discussion may also deal with specialists, since there will be someone, call him engineer, manager, superintendent, or what you will, in direct charge of these groups of motor-vehicles. At least he will be responsible for their maintenance, will have something to say about the selection of the equipment originally, will have more to say about the buying of supplies and replacements, and perhaps will have some influence on the record system and accounting practice. The specialist whose influence we will shortly consider will have even more variable duties or responsibilities when it comes to the actual use of the vehicles. In a transportation company, in which I include the commercial truckers, the motorcoach and the taxicab outfits, the executive will be an all-round man only in the smaller installations. Functions will begin to separate as the installations grow larger, with specialists for maintenance and for operation, and with the tendency for the executive over both to be of the latter type.

The situation seems to differ when the transportation activity is merely a department in a larger business. The specialist is then in most cases a maintenance executive, with only a limited interest in and authority over the hiring and supervision of the drivers; that is, in fact, on the operations of the equipment in general. A few businesses have delivery or distribution departments, it is true, which follow to a considerable extent the organization scheme of the transportation companies, but this usually happens when the driver's work is confined to the operation of his vehicle. Just as soon as the driver must become a specialist, whether it be a fuel salesman or a gas fitter, he is to a large extent under the control of other departments and has only a slight interest in the maintenance department and in

[1] M.S.A.E.—Associate editor, *Bus Transportation*, Chicago.

its efforts to keep down operating costs. That interest may be intensified, no doubt, if the outside departments are charged for the transportation service on some basis that penalizes them for misuse or neglect of the equipment.

Regardless of these variations in duties and organization, each large-scale operator is vitally concerned with matters of design and construction. This applies not only to the complete vehicle but also to wearing parts such as tires, brake-lining, spark-plugs and such items as fuels and lubricants, which bulk large in their effect on operating costs. But vital concern and influence are not necessarily the same thing. The first is more or less static; the second means or should mean a share in the progress of the art, a definite contribution to the better adaptation of motor-vehicles to their various tasks. The questions are, therefore: Has the operator any influence on design? Is that influence good, bad or indifferent? Whatever the influence is, can it be improved and made more effective? If it can be improved, how? If it cannot be improved, why?

Factory and Operators' Attitudes Compared

Let us first review the situation insofar as it relates to the standard design of vehicles developed and produced in the factory. There are two widely divergent opinions. That of the operator indicates that he provides a testing laboratory for the manufacturer and his engineer; and that the supervisors in the larger installations are acting as consulting engineers for the factory and its service department. Some of them go so far as to say that they are forced to take over functions of the production end of the factory and complete the vehicle before it can be put to work. Carried further, this opinion indicates that the operator alone is responsible for all improvements, and that the factory engineering department, with all its facilities for design and experimentation, is merely a funnel through which the operators' suggestions flow to the factory.

At the other extreme is the view held by the factory engineer, who may go so far as to deny absolutely the value of ideas or suggestions for improvements put forward by the operator, unless they can be investigated first-hand and all the surrounding and perhaps controlling conditions be taken into consideration. The specialist whose influence on design we are discussing is virtually, and not always by implication either, consigned to the lower regions peopled by the ignorant, the incompetent and, in consequence, the vicious, in effect if not in intent. From these lofty heights, supported by skilled chemists, metallurgists, experimental engineers, service engineers and what not, the factory engineering-department looks down upon the operating world, sometimes with hardly concealed pity. "We know what you ought to have! This is it! Take it!" Such is the traditional attitude of the factory, based upon contact mainly with small operators who practically always must depend upon the service station of the dealer or upon the factory branch for repair work that is in the slightest degree complicated.

Obviously, both of the foregoing opinions are overdrawn. The factory engineer certainly contributes an important share toward the improvement of design and production. On the other hand, there are many operators of the large-scale type who have personnel, system and machinery, and are entirely capable of searching out real defects and of passing upon the merits of alternative constructions. These need not have thousands of vehicles under their control, or even several hundred. With proper thought devoted to it by the management, the scientific study of equipment can be conducted on installations under the large-scale limit already mentioned.

The advent of the so-called equipment engineer in so many operating companies is hopeful, and there should be more of them. They should be young men having sound technical training. Their job should be that of keeping uptodate on new products for the vehicles, the shop or garage, of watching trial installations, and of making simple chemical and physical tests on parts and materials. If such a man is not employed, his functions must be taken over by someone else, with the disadvantages that the latter usually must give preference to other tasks in the maintenance department and that the study of equipment often must suffer.

It is probably easier for the operator near the "tank-car" margin to obtain the service of machinery than of personnel in getting data for an impartial and thorough analysis of problems relating to vehicular equipment. Testing laboratories are widely scattered over the Country, and their services can ordinarily be had at reasonable rates. Not every installation can boast of an engine dynamometer, but all operators surely should know what such a testing device can be used for and where it is located, just as they should know where a good lawyer is and when to consult him. The best time is before they get into trouble, an idea that is not well appreciated as yet in connection with the mechanical equipment. But the operator who wants to deal with measurable facts, rather than with the rule-of-thumb instincts of more or less transient workmen, is getting increasing comfort and support. An example is the portable type of brake decelerometer now used in a large number of operations. The manufacturers are helping also. One large-scale maker of axles recently offered to supply users with the Brinell hardness-numbers required for various parts, so that the parts could be checked if subjected to heat-treating while being straightened. The hot bending was not recommended, it should be said; but, if done, at least the operator could make sure that the part came up to the maker's limits for safety.

Systematic Collection of Data

System is a vague term, as is also its practice in most installations. But system to the extent of the collection of two kinds of information is practically fundamental if the operator is to pass reliable judgment in matters of design and construction. Dollars and defects describe them in two words. Most motorcoach companies collect current data on defects, having inherited the practice from the street-railway companies. Time lost on the road because of mechanical or other troubles is the important test for equipment working on schedule. Unfortunately, these are tabulated under bodies, chassis and subdivisions thereof, without any attempt to place the responsibility on a particular make or type of vehicle. The totals are a black mark against the maintenance department but do not permit of analysis to determine whether the trouble is faulty maintenance or incorrect design. Most truck operators content themselves with a record of time out for repairs, as compared with working and idle time. This labels the offending vehicle, rather than the department, but still tells nothing as to the specific difficulty.

The tendency among the motorcoach companies is to divide the maintenance expense among chassis and body parts, without allocating the results according to type or make of equipment. Possibly this practice also is inherited from the street-railway field, where the equipment is standardized to a much greater extent. Truck operators seem to work from the other end and use the individual vehicle as an accounting unit, but without segregating the expense sufficiently to assist in the selection or comparison of equipment. Tire, fuel and lubricant costs are kept separate, but then the chassis costs, almost as much as all the others put together, are lumped beyond recognition so far as their use in controlling design and construction is concerned. The exception proves the rule. One department store makes a monthly distribution of repair costs under 48 headings, these being important parts of chassis and body, so that at the end of the year a history is available for each vehicle, in the across-page and the column totals. This is more complete, it is believed, than anything done by the motorcoach companies.

The cost-keeping methods may be satisfactory in general but they are not designed for study of the peculiarities of equipment. Once installed and become a matter of routine, the ordinary system seems to make it impossible for any accurate records to be kept, if they are the least bit out of the ordinary. One of the important tasks of the equipment engineer is to handle such records at the same time he is observing the performance of equipment that is under operating test.

Methods of Improvement

Suggestions for improvement must be applied to vehicles in service as well as to those yet to be built. The improvements quickly find their way into factory practice, provided they seem to be of general utility. Many an operator who believes he is finishing the factory product is only adapting it to his own needs, a process that might for a small operator be performed at a factory branch so that the factory can limit its work to a standard line of products. But there are times when the weak link in the chain appears, or some one part fails to stand up to the performance of the others. Most manufacturers find this out very quickly and correct it as soon as possible. The time required may seem extremely long to the operator unaccustomed to factory procedure and unfamiliar with all the precautions that must be taken and with all the red tape that must *not* be cut.

If the fault is not corrected, the operator changes the equipment already in service and insists upon a different construction when new vehicles are to be delivered. One thing leads to another, as between the irresistible force and the immovable body represented by the operator and the manufacturer. The one may know the detail best suited to his service, but there is always the question as to whether it is worth the additional cost over that of a standard product only slightly different. But, as in business in general, the large buyer usually can have his way. Sometimes, having had it, he is willing to take advantage again of the manufacturer's broader experience.

Specifications for Supplies

The desire of the large-scale operator to obtain his supplies with the utmost economy is now being reflected in a widespread demand for specifications for lubricants. A number of operators have worked them out with fair satisfaction, although they admit that the specifications and the test methods can be developed further. Branded products are available to meet almost any operation requirement, and with them go engineering recommendations as to the best application. It is believed that the use of specifications would permit purchase in the open market, thus eliminating the sales expense accompanying the distribution of the branded products. Possibly the experience of the steel and automobile industries will be repeated. It took some time to formulate specifications for automobile steels, and they did not come until the demand was too strong to be ignored.

A standard specification for lubricants can be either broad or narrow. If broad, it would include all the oils on the market and would be an empty gesture. If narrow, say to meet the requirements of the large-scale operators, the specification must be based upon a clear and detailed knowledge of the operating conditions, or perhaps on various groups of these conditions. The knowledge must be developed by the operators themselves; that is, the specialists whose influence on design and construction has been summarized in this paper.

What is needed to solve the lubrication and other problems is a professional consciousness among the supervisors and the engineers engaged in the operating field. Such groups as the Sections of the Society, the Automotive Supervisors Association in Chicago, the Motor Truck Maintenance Club in New York City, and the Automotive Corporation Engineers Association on the Pacific Coast, are all doing good work, but each in a local field. The members of each of these groups have worked out good practices, which ought to be known outside their own memberships. The Operation and Maintenance Committee of the Society has made a start in analyzing and making available these methods and practices. This work must be continued by all concerned, if the operating section of the industry is to make the progress it rightfully should, considering the money invested, the number of employes and the industry's place in the economic life of the nation.

THE DISCUSSION

CHAIRMAN F. G. WHITTINGTON[2]:—Has Mr. Plimpton, in his surveys, found that anything is gained by the designers of vehicles who attempt to dictate the design of unit parts that are being manufactured by reputable manufacturers and that have been thoroughly tried and tested? What I have in mind particularly is that very often the designer of a truck or a motorcoach or even a passenger-car takes such design upon himself, as though he feels that he can design certain parts better than can the company which has been building them for years, and can dictate how they shall be built.

R. E. PLIMPTON:—Most of the makers of unit parts feel that the dictation is on the side of cheaper construction and lower costs, so far as their products are concerned. From the standpoint of the operator, I do not exactly call that a gain. The question answers

[2] M.S.A.E.—Chief engineer, Stewart-Warner Speedometer Corporation, Chicago.

itself in that it is purely one of economics. There has been much discussion in the field of electrical equipment as to whether certain parts are of the right size. The chassis manufacturer may install a certain design, but the maker of the unit parts would, if he had his own way, specify something different. So far as the operator is concerned, he must abide by the chassis manufacturer's design unless he has had sufficient experience actually to specify what he wants, but such specification does not seem to be favored by the people in the factory.

O. W. YOUNG[3]:—Some of the electric-railway companies in various locations employ motorcoach equipment as auxiliary to their regular service, serving interurban or interstate points that they do not cover by rail service. Have they made it pay, or are they in most instances operating lines to forestall competitive lines?

MR. PLIMPTON:—According to the way the accounts are figured, many of these electric railways show a loss in their motorcoach operation, although I believe that not many of them are worried much about it. The vehicles are as a rule installed on routes where the railway companies otherwise would have had to install trolley service at a much greater expense; so, figuring it in another way, their net income is increased by the motorcoach operation. They hold themselves out as public servants desiring a monopoly in a particular territory. The only way they can keep and deserve that status is to serve all the territory. They do it much more economically by putting in motorcoach service.

WALTER MARTINS[4]:—Concerning the safety of passengers, I rode from Milwaukee to Chicago recently and observed that there is almost a cut-throat business between two rival motorcoach companies. It seemed unsafe to ride in the vehicles because the drivers pass one another and almost throw each other's vehicles off the road. Are there any definite regulations in effect that control the speed and the way in which drivers handle the motorcoaches on the highways?

MR. PLIMPTON:—Definite regulations are in force. Each State or county has the same police powers that it ever had, and their regulations also cover intrastate operation. The only thing that the regulations cannot do is to forbid operation. That would be hindrance and an obstruction of interstate commerce. While the vehicles are being operated, the authorities have every right to and should control them, keeping them down as to speed and seeing that they are operated safely just as they do for the intrastate vehicles that are under their local control.

COOPERATION OF ASSOCIATIONS

WALTER C. BECKER[5]:—As to cooperation of the different associations that practically have the same purposes, what method can we use to get them together? If we do get them together, will there be any mutual result?

MR. PLIMPTON:—I am glad Mr. Becker raised that question. We have had difficulty in this respect in the work of the Operation and Maintenance Committee. Subjects were submitted to the Committee by men active in operation work and we started to study them and to collect statistics, opinions and experimental data from different people in the industry and from different members of the Committee; but after a while we were told by some of them that it was none of our business. The Society is no longer an organization composed solely of engineers from the factories, although it started that way, but many people have the idea that it still continues to represent only the designers and the engineers in the factories. The matter came up 3 years ago. We found that operation and maintenance men already were members and taking active part in the work. They were presenting papers, serving on committees and the like; so the Constitution of the Society was changed to open the full-member grade to those who had responsible charge of maintenance or operation. From that time on we have gone forward and have had more activity. The membership interested in operation now includes men directly from the operating field, men from the factories who are particularly interested in the application of vehicles, men from the service departments, and transportation engineers who are studying the economics of operation and maintenance. All these men are also represented on the committee.

Undoubtedly, certain questions should be considered by the fleet-operators' organizations. At the meetings of the Society attended by members of such organizations as Mr. Becker mentions, they should cooperate as they did recently on the Pacific Coast; three organizations were represented, the Society, and associations of service managers and of operators of vehicles. All these have a different viewpoint on the subject and something different to contribute. The only way in which we can get ahead is to get them together several times a year to discuss subjects of mutual interest.

E. S. ANDERSON[6]:—I have attended a number of joint meetings of the character Mr. Plimpton describes and at which most interesting discussions have taken place. The meetings have been much more lively than many of the meetings attended only by members of the Society.

ALLOCATION OF COST-ACCOUNTING WORK

Is it possible for the fleet engineer or superintendent to have charge of the accounting or costs? Which do you prefer, to have the cost accounting of the fleet come under the supervision of the superintendent's office or that of the accounting department of the company which owns the fleet?

MR. PLIMPTON:—My feeling is that the more interest the engineer or superintendent in charge takes in accounting and the more he knows about it, the more valuable he is to himself and to his employer. It is not possible to put all the accounting for motor-vehicles into the operating department, but I think the figures could be accumulated there and that then they would mean much more to the department and be of more value. There comes a time, of course, when the figures must be assembled and transferred into the general accounting system.

Two general schemes of accounting are followed by these large operating businesses. Some of them are wholly centralized; in such cases they start from the very bottom, with the raw material, and accumulate all the data in a central department. In others, each department has its separate accounting system. The subject is a good one for discussion.

[3] M.S.A.E.—Sales manager, tractor and implement bearings, Hyatt Roller Bearing Co., Chicago.

[4] A.S.A.E.—Manager of service department, Fashion Automobile Station, Chicago.

[5] A.S.A.E.—Assistant superintendent of utility department, Chicago Surface Lines, Chicago.

[6] M.S.A.E.—Transportation superintendent, Great Atlantic & Pacific Tea Co., Chicago.

Quality of Replacement Parts

J. W. Tierney[7]:—I believe that, in the operations to which Mr. Plimpton refers, the guiding principle is supposed to be to design a vehicle and its different parts so that it will result in the minimum cost per mile. Most of the manufacturers are trying to incorporate in their products units the cost per mile of which is low. Do the users follow this same principle? In other words, do they try to replace a part which is finally worn out with a high-grade part the cost per mile of which is low, or is it the tendency to buy something as cheap as possible, figuring that when it is worn out they will throw it away and buy another one? What is the tendency among large-scale fleet-operators?

Mr. Plimpton:—My offhand opinion is that many operators are likely to be shortsighted and buy materials or parts that really do not represent the best value. When they employ men who are making a scientific analysis of these problems, the situation is changed. That is why I advocate some of the things I mentioned in the paper. There can be a great improvement, even among the large operators.

Mr. Anderson:—In buying replacement parts and various parts to be used as automotive equipment, service is one great factor that influences the determination of what parts to buy. Tires are very likely the best general example. The attitude and service of the local distributing-point or representative of the tire company has an influence on the purchasing. Also, several springs are on the market which meet the specifications satisfactorily, and the service furnished with them is an important item. I do not know of many parts used as equipment for which the cost per mile could be determined.

Mr. Tierney:—Some operators believe that it is economical for them to install the cheapest parts they can buy. Others feel they want the most efficient design for the work for which it is intended, even though the first cost may be greater. What is the consensus of opinion among the operators?

Harvey E. Tyler[8]:—In the case of a small transportation line, the owner operated several Ford cars and one higher-priced chassis. Considering first cost, interest on the investment and the ease of obtaining Ford-car repairs, the Ford vehicles had been very much the cheaper. The vehicles were running only 3000 or 4000 miles per year and, on such a basis, the repairs would not be extensive, so the cheaper outfit would be the most economical in the long run. But for an outfit that is running continuously and piles up a high mileage, as with motorcoaches on the streets, that would not be true. The same principle would apply generally, in my opinion.

Robert I. Dick[9]:—Approximately one out of every 25 buyers demands quality; the others seem to be more interested in buying on a price basis. I know of a few contractors who buy equipment and specify to the maker just what is to be put into it, and of several operators who demand a certain type of engine because they figure the maintenance cost is less; but for one such buyer there are about 25 who buy on a price basis. In the class that demands quality, when something does break down they study the failure and endeavor to devise some means that will avoid a future breakdown, whereas the others are more interested in getting the job running again at the minimum cost. I know from past experience that the automotive user or truck operator will tend more strongly toward price buying than the contractor, because contractors in general are, to a large extent, engineers. Perhaps they do not know much about mechanical engineering, but they have a more comprehensive idea of all the engineering features than do the motorcoach and the motor-truck operators.

Chairman Whittington:—Mr. Dick mentions that about one out of 25 buys for quality, the others on a price basis. But the vendor is likely to give quality at the low price. The buyer will bargain over the price, will get the product at that price and will develop troubles that revert to the manufacturer of the part, who must make good on his product. Eventually, the manufacturer boosts the quality until he has it as good as he should have it in the first place at the same price. That is happening all the time.

Mr. Young:—Usually, when the quality is raised the price is lowered.

Rebuilding of Batteries

Mr. Plimpton:—In recent discussions I have had with battery manufacturers, they seem to feel that it is wrong for the large-scale operators to rebuild batteries as they do. The reason given is that it is much more expensive than it is to buy new batteries. What is the correct method of figuring the cost so that the expense of building or rebuilding batteries can be compared with the cost of new batteries?

Mr. Tierney:—The correct method is to include the cost of all material, labor, charging current and overhead costs to arrive at the total cost of the rebuilt battery. To determine if this is economical, the cost per month or per mile of this rebuilt battery should be compared with the cost per mile or per month of a new battery. Some large-scale operators make a practice of installing new positive plates and separators, using the old rubber case, negative plates, covers and connectors. The judgment of a competent man to determine if the battery is physically fit for renewal is very necessary and important.

Service Guarantees

Roy J. Laurance[10]:—The question of whether to buy on the quality basis or on the price basis interests me particularly with reference to motor-trucks. Is it good business to buy one make of truck or high-priced equipment if used in localities where service is poor, when the manufacturers of cheaper cars are giving service in those localities?

The question of purchasing replacement springs from the truck manufacturer rather than from a jobber or spring manufacturer is also interesting and it is better known that they can be purchased from the latter source at considerably better prices.

Mr. Plimpton:—Conditions might exist that would make it cheaper in the end to buy the cheaper product and have assurance of immediate service. It is a broad subject. An operator who buys any part like springs is more or less in the dark. What the typical equipment-engineer is doing is to watch a part like that in service to see whether the value that he gets out of it is such that he wants to go on buying it. Operators are short-circuiting the manufacturers all over the Coun-

[7] A.S.A.E.—Sales engineer, Electric Storage Battery Co., Chicago.

[8] M.S.A.E.—Engineer, fuel and lubrication division, Stewart-Warner Speedometer Corporation, Chicago.

[9] M.S.A.E.—Chief engineer, Buhl Co., Chicago.

[10] Superintendent of motor equipment, Cudahy Packing Co., Chicago.

try, there is no doubt about it. If they can get something from a jobber that will really do the same work at less cost, they are undoubtedly justified in buying it.

MR. YOUNG:—I think that whole question never would have been much of a question if the original manufacturers had given sufficient thought to the service angle and to the distribution of the legitimate products that are serviced. Apparently, insufficient thought has been devoted to that and this has led to the making of parts of indifferent quality by small companies who get a wide distribution of them just because there is that demand. The automotive industry as a whole has been so busy making original units that it has missed that opportunity. It is difficult to realize what this replacement-parts business has amounted to but it is an item of hundreds of millions of dollars. The independent garages and the "alley" garages have been the main supporters of the manufacturers of replacement parts. Some of the largest organizations have made an intensive study of the subject and have secured a wider distribution, thus making it much easier to get these replacement parts. That business is on a sounder basis today than it ever was before, and will be increasingly so as time goes on. I look forward to the time when legitimate authorized serviced parts of known quality will be the only parts that will receive major recognition from people who really want service and who have the economics of their problem in hand.

MR. MARTINS:—I am not familiar with the production end of the products as they are used by the large-scale car-builders or manufacturers, but I believe it is true that they let contracts for different materials, such as spring bolts, springs, axles and other items, to various manufacturers. It is also true that, when they supply the demand of the particular men who have placed the contract with them, these manufacturers may continue to manufacture more of the same articles and put them on the market through the jobber. I believe it is true also that these jobbers sell the same units to the garage men at a discount which the car-manufacturer's distributor or dealer does not give, the result being that the garage men buy the products from the jobber who sells at a lower price.

MR. ANDERSON:—Relative to replacement material, our policy of purchasing is determined by the adequacy of the service guarantees for a given product. The distributors of some of the standard replacement parts give better service than the factories. In Chicago, considerable time is lost in trying to get the parts from the distributors' stockrooms, and that has had its effect on determining from what company the parts are to be purchased.

As to the question of whether an operator can rebuild his own storage batteries or should buy new ones, I think the buying of new batteries is more economical. If the batteries are rebuilt, very little of the original battery is likely to be used. The material costs $5 or $6 and the labor cost is around $1.50. For very little more than that, new batteries that have a service guarantee can be bought and the batteries will be maintained by the manufacturer for a definite period. That in itself is a desirable item.

CHOICE OF PARTS FOR REBUILDING

MR. PLIMPTON:—Does not the trend toward the buying of authorized parts apply more to the small user or to the private passenger-car owner? It seems to me that the large-scale operators are going to preserve their own independence more and more. If they can save anything, they are going to do it. Unless the authorized service-stations already mentioned can give recognition to their buying power in the form of price and service, I cannot see that very much can be done as against some of the other people who are catering to a large-scale buyer who does not need to depend for the bulk of his business upon sale through what are considered the authorized channels; that is, to the dealers' service-stations and, occasionally, to the bulk of the passenger-car agencies.

MR. YOUNG:—I have no particular thought in connection with whether the buyers are small or large. Mr. Plimpton raises the question whether the small-scale car-owner or the individual owner is much of a factor in the choice of the parts that are put into a rebuilt job or into a repair job. I think that neither one ever has had much influence. The owner of a small garage or repair station looks at the matter entirely from the viewpoint of getting the part needed as quickly as possible and at the price that makes the job most attractive to him.

When I mentioned the tremendous volume of repair parts, I had in mind the parts applying to passenger-cars. As I said, the car manufacturers have overlooked an opportunity in regard to the distribution of these parts. They did not have them easily available or generally distributed, and they left that field open to the replacement-parts manufacturer. That condition is being corrected by an intensive study and a much wider and more efficient distribution of their so-called authorized parts. I did not mean to decry, either, the service which the individual manufacturer of replacement parts has rendered to the industry as a whole. He has done a good job. There are many reputable builders who are really building excellent replacement parts, independent of the original manufacturer, and they have met a demand and filled a need. I think that there is right now, and that there always will be, a place for them. I know several local spring manufacturers who carry and are in a position to replace springs for a great number of different types and sizes of cars, and they also have production business so that they are equipped to do a real job. They can furnish good springs and they can furnish them on short notice; they carry large stocks, larger than any individual company could possibly carry, and there is a real place for them.

I want to emphasize the points that the independent parts-makers have filled a real need and that there is a continued place for them in certain fields. Where production of any unit is large, it is reasonable to suppose that the original manufacturer can give a better part for less money, and I think that this is the tendency. Comparing replacement-parts lists today with those of a very few years ago, we find that there is considerably less margin of profit and that the idea of service guarantees is gaining momentum. They want the volume business. They know that volume business will justify lower prices and much better service and will make possible a much wider distribution.

MR. TIERNEY:—I have talked with our representative who handles the fleet operation in Chicago. He tells me that it was the tendency of the fleet owners a few years ago to buy what they could to get their trucks to run. He tells me there is a distinct reversal. Now, the large-scale high-grade operators are trying to buy the quality products. There has been a distinct tendency in that direction.

Integrated Production

Discussion of E. P. Blanchard's Production Meeting Paper[1]

WE are in a new era of production that has been made possible by the broader vision of the production engineer, who is now an established factor in industry because of the demand for reduced production costs. The two factors over which he has control are labor and machinery. Labor cost is of diminishing significance as machinery takes over an increasing proportion of the responsibility for performance.

To the two production principles of the division of labor and the transfer of skill to machinery is added a third principle deduced from facts observed in modern production practice. This principle is integrated production, the combining of work units, which are the smallest possible divisions into which operations are broken down by the time-study man, so that a number of identical or similar operations are performed simultaneously by multiple tools, with the maximum efficiency and economy for each tool or each work unit.

This calls for increasingly greater refinement, from multiple tooling to provision for performing at one time operations governed by differing conditions. It can be carried to any extent justified by resulting economy. The point at which economy ceases to increase is determined by calculating carrying charges on the equipment against the operating cost of production. On greater quantities, as refinement is carried to greater limits, the savings in each case become less; the economy curve flattens out considerably long before "mass production" is reached.

Integrated production also combines the division of labor, the transfer of intelligence to machines, and the simultaneous performance of work units in a way to comprise a complete process or method performed in the shortest possible time. This results in smaller inventories of raw materials and materials in process, greater flexibility in the manufacturing process, quicker turnover from raw material to finished product, shorter financing periods, less money required and less tied up in forms subject to loss. Such savings, on a National scale and in the volume represented by the automotive industry, must contribute to the present favorable financial situation. Thus the production engineer is an important factor in such an ultimate phenomenon as the National prosperity.

In the discussion one member tells how "simultation" with multiple-head machines made possible in 6 years a reduction of incandescent-lamp factories from 10 to 3 and of direct-labor operatives from 4500 to 1500 with a simultaneous increase in production of 62.5 per cent. Other points brought out are that economical production can be obtained in a period of reduced schedule by keeping all the machines in a group running but reducing their speed and reducing the number of operators; that cost can be reduced by putting money into machinery and reducing the labor-cost; that there is economy in setting the equipment for a production a little greater than the planned quantity; and that there is a critical point at which the cost per piece becomes greater with the simple machine than with the more refined and more expensive machine and at which a change in method should be made.

J. D. CEADER[2]:—Mr. Blanchard struck a responsive chord in my mind when I recall the number of things the company with which I am connected has done in the last 4 or 5 years in the line of what he calls simultation. In 1921 the company made 80,000,000 miniature incandescent lamps, perhaps half of them for the automobile trade. These were made by semi-automatic methods on slow-speed machines in 10 factories in the Country employing about 4500 operators. In the last 6 years simultation applied to multiple-head equipment has made possible a reduction in the number of factories to three, with a production increase from 80,000,000 miniature lamps in 1921 to 130,000,000, estimated, this year, and has also resulted in a reduction of direct-labor operatives from 4500 in 1921 to 1500 in 1927.

The greater part of this progress has been accomplished as a result of the development of high-speed multiple-head equipment and the grouping of such equipment. It has reduced costs and prices on lamps in a period when the prices of most other manufactured articles have increased.

JOHN YOUNGER[3]:—Production men are likely to forget, sometimes, that there are two branches of production, one occupied with the mechanical work of machining and the other occupied with the economics of machining and with the decrease of ultimate cost. Economics is very important in the latter item and I suggest that economics be studied more and more by production men. The subject dealt with in Mr. Blanchard's paper has a most important bearing on the economics of manufacture.

EUGENE BOUTON[4]:—Mr. Blanchard spoke of breaking up the cuts by numerous tools in integrated production so that the cuts would balance as nearly as possible. But where there is a group of five or six machines and the production schedule is suddenly reduced it sometimes occurs that any one of the group of machines can produce more than the schedule requires. It has been my experience that where we had five operators on five machines the speed of the machines would be reduced so that they would give the production scheduled and would be operated by one, two or perhaps three men. That has a bearing on the economics of which Mr. Younger spoke; the machine-tools can be slowed down rather than speeded up to get economical production.

E. P. BLANCHARD:—I suggested that simultation is

[1] Published in THE JOURNAL for October, 1927, p. 375. The author is advertising and assistant sales manager of the Bullard Machine Tool Co., Bridgeport, Conn., and is a member of the Society.

[2] M.S.A.E.—Manufacturing engineer, incandescent lamp department, General Electric Co., East Cleveland, Ohio.

[3] M.S.A.E.—President and editor, *Automotive Abstracts*, Columbus, Ohio.

[4] M.S.A.E.—Supervisor of time study, Chandler-Cleveland Motors Corporation, Cleveland.

a proportioning of the carrying charges of investment against the operating costs. Under the conditions mentioned by Mr. Bouton, it will cost you less to put more investment into machinery and to reduce the labor-cost complement in the cost of the work piece. More machines are run with fewer men and the production is a little less perhaps, but you can better afford to put the money into machinery and pay the carrying charges on the investment than to pass it out in labor charges.

N. G. SHIDLE[5]:—In the paper you said that in every job there is some point at which maximum efficiency is reached as related to the overhead carrying charges on the machine, and that from an economic standpoint you allow for a peak of efficiency somewhat above the expected quantity.

Why is it logical to do that in view of the fact that most of the operating will be considerably below the peak of efficiency? In the automotive industry I believe the operations very frequently have been at quantities below those estimated in the beginning; that is, we have high peaks in production but frequently operate over a considerable period below the schedule previously estimated. Would one not get into some trouble if he set the peak of efficiency a little higher than expected production?

This whole paper seems to me to be tremendously important, both in the questions it raises and in the general line of approach to the mechanical problems that confront the industry. I believe there will have to be a great deal more of this economic approach to production problems, as well as the more detailed mechanical approach which we have had. We are entering a period in which much closer coordination between all the elements in any organization is necessary, because we cannot have economic and efficient production unless the company as a whole is able to make a very close estimate of its rate of production for a reasonable period in advance. The man who is forecasting sales, analyzing markets, following current business trends and predicting those trends, not on the basis of "pepping up" the sales force but with the object of proper management of the plant, is going to be a larger factor than before; and I believe the success of that man's work will bear heavily upon the efficiency of future automotive production.

MR. BLANCHARD:—Sometimes exceptional cases are regarded as indicating the rule when they are not the rule at all. Mr. Bouton's suggestion that a little larger investment in equipment and a lessening of the labor required, though it produces fewer pieces, results in lower cost per piece proves Mr. Shidle's point. If production is set at a normal figure and the production engineer has set a peak which he hopes to attain, but which, from his past estimates, he knows is 10 or 30 per cent high, he can call that peak high enough. But I know there is an increment in economy in setting the equipment for a quantity that is just a little greater than that he plans for. Putting money into machinery and replacing it through lower cost of overhead per unit is cheaper in the end and results in lower cost per piece than to spend it for manual labor or to accept a lesser degree of refinement and put more work into the cost of producing the piece.

The overhead cost of operating a machine is constant. For a given production quantity, a machine is bought and installed and, except for a few variables of power consumed, operating supplies, and the like, the carrying charges are practically a straight line. For the simple machine that cost runs close to the base line. For the more complicated machine the carrying charge is higher because more money is invested in the machine. Now find the operating-cost factor and combine these two, as in Fig. 1. There is, for instance, the set-up cost of the machine. Develop from the less expensive machine the time required for setting up the machine and producing the first piece. After getting into production the operating cost is reduced as quantities increase. With the relatively high component of labor cost that is in the simple machine, a certain labor cost is required for each piece in production, and the production cost never can be brought below a certain point.

The more refined machine represents a greater investment but requires a smaller component of labor cost

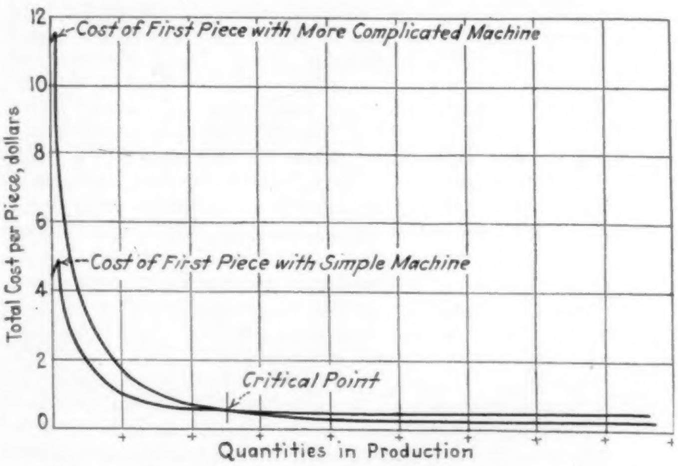

FIG. 1—PRODUCTION COST PER PIECE AT VARIOUS QUANTITIES WITH SIMPLE AND WITH MORE COMPLICATED MACHINES

Cost of the First Piece Produced, Indicated by Peaks of the Two Curves, Is the Sum of the Cost of Set-Up and of the Cost of Making One Piece. Subsequently, the Cost of One Piece at Any Quantity Is the Operating Cost of the Machine Plus the Set-Up Cost Divided by the Quantity Produced. The Less Refined Method Costs Less To Set Up but the Constant Operating Cost per Piece Makes Impossible the Lowest Ultimate Cost. Where the Two Curves Intersect Is the Critical Point That Determines the Economic Quantity at Which To Change from the Simple to the More Refined and More Expensive Machine

in the cost per piece. Up to a certain production quantity, the less refined, cheaper machine is cheaper to use, but when the critical point is passed, the cost per piece is less with the more expensive machine. In carrying a series of variously refined machines for the same purpose through a plotted cost per piece for the production quantities, a series of cost curves cross one another, but the curve that starts highest and represents the greatest refinement method drops lowest in the end.

E. F. DUBRUL[6]:—It struck me that Mr. Blanchard has formulated something from the production man's side that is new to the economist. If his formula is concealed somewhere in some of the leading books on economics, I have not found any economist who brings out this principle as Mr. Blanchard has developed it. I think it is an original contribution to economic literature. If the production men who are actually applying this principle of integrated production are made conscious of it and have it clearly in mind in working out these problems, society will get considerably more benefit from what they are trying to do. I think Mr. Blanch-

[5] A.S.A.E.—Directing editor, Chilton Class Journal Co., Philadelphia.

[6] General manager, National Machine Tool Builders Association, Cincinnati.

ard should go down in the history of economic theory as the first man to formulate this principle.

G. A. SCHREIBER[7]:—Yesterday at the machinery exhibition there were from 40 to 50 men from Europe who seemed more anxious than ever before to learn about our machine-tools and of such methods as Mr. Blanchard has touched upon again. Not having been in Europe for about 12 years, I spent several months over there last year. In Italy, France, Germany and England the greatest importance seemed to rest always with the designer, and he was the all-round dictator. However, this condition existed only until last year, because their designs of cars, trucks, tractors, or anything else was, as a rule, so complicated that the product cost a great deal more to manufacture than in the United States, where we have good cooperation between the designer, the production engineers and the machine-tool builders. This harmony has resulted in better motor-cars and other units at such low prices that it seemed to me, while I was over there, that the best dealers in Europe were fighting for American car and truck dealerships. Our cars sell there much easier than their native cars in spite of our boxing, transportation costs, and the foreign import duty.

The cooperation here should be emphasized again and again, because the fact that a large percentage of our automotive products are sold in foreign fields is largely responsible for our continued prosperity. It is vital that our production engineers, designers and all other men always work harmoniously together when a new product is created.

[7] M.S.A.E.—Consulting engineer, Detroit.

External Cylindrical Honing

Discussion of L. A. Becker's Production Meeting Paper[1]

BECAUSE of the slowness and inaccuracy of hand-polishing methods, a machine has been developed for honing the bearing surfaces of crankshafts. The author analyzes the reasons that influenced this development and outlines the problems that had to be overcome.

A clear statement is given of the variables to be controlled in crankshaft honing.

Honing is said to produce a bearing surface smoother and more true to form than can be produced by grinding alone or by grinding and polishing; to make possible smaller bearing-clearances than are now generally needed; to eliminate the usual initial wear; and to reduce the bad effects of oil-dilution.

The application of honing to other bearing-surfaces is foreseen.

Photographs show the construction of the honing machine and its elements, and also samples of its work.

L. A. BECKER:—During the building of this machine we tried different methods of sharpening the stones. Our first attempt was to use the stones, which are ½ in. square and cut to the proper length, in their original condition. Until the contact surface wore into a considerable arc we did not get satisfactory results. Neither did a shaft wound with emery cloth give the result we were after. Then we tried grinding wheels of the width of the bearings to be ground, assembled on a shaft, but the wheels and the stones simply glazed each other; so we finally developed the little machine with a diamond for dressing the stones, which has proved very satisfactory.

FRED J. BEDFORD[2]:—What percentages of lard oil and kerosene oil make the best solution for honing?

MR. BECKER:—Kerosene alone is very good, and more than 25 per cent of lard oil would interfere with the cutting.

EUGENE BOUTON[3]:—Have you tried soluble oil as a lubricant? A kerosene and lard oil solution has a tendency to load the wheel in cylindrical and internal grinding operations, whereas a soluble oil flushes the wheel and the work that is being ground, and prevents loading.

MR. BECKER:—We have discussed that and probably will try it but have not done so yet. Our stones do not load and it would be hard to improve on their work, but we shall be interested to find out if soluble oil will make any improvement in the operation of the honing machine.

MR. BOUTON:—Have you had any experience with the honing of pistons?

MR. BECKER:—We honed every possible part of a certain engine, including the cylinders, the crankshaft, the pistons and the piston pins, and we diamond-bored the bearings. This engine was assembled, run at full throttle immediately, and given a severe block-test. When it was torn down it showed no appreciable wear on any surface that had been honed. At the beginning of the block test this engine developed 6 per cent more power than a standard engine, and the friction was reduced from 4 to 3 hp., a reduction of 25 per cent.

This block test was repeated on a second engine of the same make with identical results and the engine was placed in a chassis and run for 2000 miles. It was then torn down and showed no measurable wear on any honed or diamond-bored surface. The engine was reassembled and is now continually on the road in extremely hard service. After many thousands of miles its record is still perfect. The initial wear was taken out by honing before the engine was first assembled, and no doubt many thousands of miles were added to its life thereby.

[1] This paper, an abstract of which is given herewith, was printed in THE JOURNAL for October, 1927, p. 377. The author is chief engineer of A. P. Schraner & Co., Cleveland.

[2] M.S.A.E.—Lubricating department sales manager, Magnolia Petroleum Co., Dallas, Tex.

[3] M.S.A.E.—Superintendent of time study, Chandler-Cleveland Motors Corporation, Cleveland.

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The General Theory of Container Use

By Bernard Allen[1] Transportation Meeting Paper

UNIT containers for the transportation of freight by rail and highway have been in use in Europe for three-quarters of a century. They are now used in this Country by three large railroads, and have been used for years by a New York City storage and van company for the shipment of household goods to all countries of the world. A steamship company also uses them for transporting cargo between New York City and the British West Indies.

Containers have come into prominence of late in purely terminal freight movements by motor-vehicle, and various systems of container and roll-off-body operations are conducted in many parts of the Country. Some of the success of this system lies in savings effected by reduced handlings of individual packages and the dispatch with which a quantity of packages can be put on and taken off of the road vehicle, thereby saving waiting time of the vehicle.

Maximum benefits from railroad-container operation will not be secured until containers are adopted by all the railroads and interchanged among them. The author lists the major advantages to the railroad as (*a*) reduction in terminal handling of freight, (*b*) reduction in transfer handling, (*c*) increase in car efficiency, (*d*) relief of terminal congestion, and (*e*) elimination of theft and reduction of damage claims. Advantages to be gained by the shipper are (*a*) faster delivery of less-than-carload freight, (*b*) reduction in packing and crating, and (*c*) reduction in cartage costs.

The present field for container use is outlined as approximately 63 per cent of present less-than-carload traffic and the moving of minimum carload lots in comparatively short-haul freight movement. Its operation can be extended to longer-haul traffic as its economic value in the latter field is proved.

IN his earliest endeavors to transport his belongings, man adopted the idea of containers by bundling together in one package such goods as by their weight or bulk could be handled as a unit with the facilities at his command. As more modern transportation facilities, such as the earlier railroads and improved highways, came into use, the shipping unit was increased to such size and weight as could be wheeled into and out of cars onto wagons for movement to its destination.

The unit freight container as now known came into prominence first through its use in England, where the railroads were of different gage, the container offering the facility for interchange of traffic between these roads. As early as 1845 a patent on container design was granted by the British Patent Office to a man named Powell. The Powell idea was to facilitate the transferring of the merchandise between wide-gage and narrow-gage cars then in use in England. This container could be and was loaded upon the drays in use at that time, thus making possible the loading of the unit at the origin of the freight and unloading it at its destination.

Use of the unit container extended to Italy, where Italian patent rights were issued in 1879. Following this, in 1887, a French patent was issued for its use on the French railroads. This was followed by use of the container in other countries of Europe and also in some isolated operations in both North and South America.

Probably the most comprehensive container scheme so far advanced was that advocated by A. W. Gattie, who, in 1910, presented an l.c.l.-container proposal to the Board of Trade in London. His system contemplated one central freight station for the whole city of London. This station was to have several floors, a cellar and two sub-cellars, all equipped with transfer trucks, overhead cranes, runways, transfer wagons and l.c.l. containers. These would enable goods to be loaded into containers at the stores of the merchants, transferred thence by lorries to the central freight house, there loaded upon suitable cars, and transported by rail to the freight house nearest their destination, thence unloaded from the railroad cars to lorries and conveyed to the consignee, all in unbroken shipments.

Probably no feature of transportation by rail aroused greater controversy in England than did the Gattie proposal. Investigations were ordered by parliament, and such men as Sir Eric Geddes, the heads of transportation departments of the British railroads, Gattie, and many others were called to give their opinions for and against the scheme. On Jan. 2, 1920, the *Railway Gazette* published an article announcing the definite rejection of the plan. It seems, however, that had this scheme been put into operation gradually it would have succeeded. An idea of the size of this undertaking can be had from the cost involved, which, at pre-war prices, was estimated to amount to $1,500,000,000.

Container Operation in This Country

In the United States we have unit-container operations on the New York Central, the West Shore, and the Boston & Maine railroads. There are other special container operations; among them is that conducted by the Bowling Green Storage & Van Co., of New York City, whose containers are loaded with household effects in the United States and shipped to almost all countries of the world. Some of these containers are out of the hands of the owner for periods of more than a year, as they are not returned to New York City empty but wait for a return load. Another interesting operation is conducted by the Munson Steamship Line, which owns containers and operates them from New York City to the British West Indies. The containers make possible the loading of the cargo on lighters in the roadsteads in rough weather without damage from breaking or by water, and also protect the cargo against pilferage.

Of late the container has come into prominence in purely terminal freight movements by motor-vehicle. Various systems of container and roll-off-body operations are conducted in many parts of the Country. Some of their success lies in the savings effected by reduced

[1] Scarr Transportation Service, New York City.

handlings of the freight, as well as the dispatch with which the load can be put on or taken off the road vehicle, thereby reducing the non-productive time of a comparatively expensive vehicle. As in railroad-container movements, the terminal container enables the movement of merchandise with less crating or packing than by the old method, due largely to the fact that the container is loaded and unloaded in the factory or warehouse, where the time consumed does not enter into the vehicle operating cost, as does loading or unloading a waiting truck at the door.

Full Benefit Depends on General Use

The economic justification for container operation in either the industrial or the railroad field can be only that the total work in transporting merchandise is performed at less cost than by any other method, or at the same or even greater cost but with a saving in time that is worth to the community any extra cost of the operation.

Savings to be derived from railroad-container operation depend largely upon the extent to which the container is used by the railroads of the Country. Small individual operations on a portion of one railroad system will be of value only to the territory served, and will not be so beneficial even to this territory as if the use were extended to the whole system. The maximum benefits from container use will not be secured until containers are adopted by all the railroads, with interchange arrangements such as now exist for the movement of freight cars. The increase in labor rates during the last few years has caused the railroads, as well as industry in general, to adopt mechanical devices that will replace the use of man-power. These wage increases make it profitable to use mechanical devices that would not be justified economically under a low wage scale. The unit container is one of these devices; it offers savings in both time and cost of delivery of less-than-carload freight.

Benefits to the Railroads

Reduction in Terminal Handling of Freight.—From the railroad point of view the most important benefit of the container method is the elimination of four handlings by men of the individual packages of each consignment. Under the present l.c.l. handling method, the following handlings of freight are necessary:

(1) Freight is loaded from the originating warehouse to the truck
(2) Unloaded from the truck to the freight shed
(3) Loaded from the shed to the car
(4) Unloaded from the car at the destination station
(5) Loaded on the truck for delivery
(6) Unloaded from the truck to the warehouse at destination

With container operation, the freight is loaded into the container at the point of origin and unloaded at destination; the four intermediate handlings are accomplished by moving the container with its load as a unit.

Reduction of Transfer Handlings.—Container use will reduce the amount of transfer handling by decreasing the size of the shipping unit from a 40-ton box-car to a container of 2 to 5-tons capacity, thereby allowing more definite destination classification at the shipping point. Many consignments now moving in transfer cars can be handled direct as a unit in a container. Containers can be loaded with two or three consignments and shipped direct to destination points that do not warrant the set-up of a car under present operations.

Increases in Car Efficiency.—Container use will increase the daily mileage and the average loading of cars assigned to this service. Container cars can be loaded or unloaded in approximately 20 min., leaving the cars free for road use rather than tied up at the freight shed all day as at present. Whereas cars are now loaded for the same destination with small quantities of freight from different points, each of these shipments would, under container operation, move in a container rather than in a car, and several containers would be loaded in one car, thereby increasing the net tons per car as well as reducing the number of cars required to move a given quantity of freight.

Relief of Terminal Congestion.—Container use will help to relieve terminal congestion in both yards and freight sheds by increasing the amount of traffic that can be handled through a given terminal space, due to the rapidity with which the freight-cars can be loaded and unloaded. Where a crane is provided, container traffic can be handled by the crane on team tracks, thus relieving the freight shed of the congestion usually caused by small-package freight. Where cranes are not available, containers can be moved directly from flat-cars and box-cars on team tracks to road trucks by the use of a simple detachable moving-device.

In addition to the foregoing, the increased car loading will reduce the number of cars necessary to handle a given amount of traffic through a terminal.

Elimination of Theft and Damage Claims.—Containers will eliminate theft claims and reduce damage claims to the vanishing point. When containers are loaded on cars so that the doors cannot be opened while in transit, pilferage is impossible. The doors can be locked at the point of origin by the shipper and unlocked at destination by the consignee, thus affording protection to the contents while in transit through the streets as well as while on the rails.

Damage losses are largely proportional to the number of handlings the freight receives. With the elimination of four of the present minimum of six handlings, damage claims from this source will be reduced proportionally. In addition, the smaller and more compact shipping unit, which makes possible better stowing of freight, will result in less damage from shifting of the cargo while en route.

Advantages To Be Gained by Shippers

Faster Handling of L.C.L. Freight.—From the point of view of the shipping public, an important benefit will be the faster delivery of less-than-carload freight, as overnight delivery can be accomplished in every instance when it can be done with a highway truck. Container use will speed up the delivery of l.c.l. freight by the use of organized trucking facilities at each end of the rail haul. The container can be loaded on the truck late in the afternoon, transferred to a container car (if necessary, at some point in the yard other than the freight house), be moved at night to any point within a radius of 150 miles, and delivery can be made at destination by truck early the next morning.

Reduction in Packing and Crating.—Containers will largely eliminate costly packing and crating. If the containers are loaded at the point of origin and unloaded at destination, the packing and crating of a great many commodities can be eliminated entirely and can be modified materially with others. This will reduce the cost of crating for shipment and also decrease the weight on which freight must be paid.

Reduction in Cartage Costs.—Finally, container use will reduce cartage costs by reducing the standing time required for loading and unloading and by increasing the average load per truck. The cartage costs at both origin and destination can be reduced by (*a*) increasing the tonnage per truck load and (*b*) reducing the time of loading and unloading by handling one unit instead of the individual packages comprising the shipment.

An analysis of the loading of trucks of different tonnage capacities moving from a railroad's freight sheds in a large city shows average loads as follows:

Truck Capacity, tons	2	3	4	5	6	7
Average Load per Trip, lb.	594	946	832	832	918	1,406

With container operation and loads of from 1000 to 7000 lb. per container, and with the terminal operation under one head, capacity loadings for trucks can be obtained easily; so a 5-ton truck will move 10,000 lb. rather than 832 lb., or 8.3 per cent of capacity, as at present.

In addition to increasing the load, it will reduce the waiting time for the truck by decreasing the number of trips necessary to handle the same volume of traffic.

Two Container Sizes Seem Logical

The container should be of such size and design as will best suit the performance of the work it is intended to do. The average weight of an l.c.l. shipment, as many railroads have determined, ranges between 650 and 750 lb. The results of a survey made by me, covering a large number of l.c.l. consignments where the average weight per consignment was 680 lb., showed that 27 per cent of the freight, by weight, runs between 3000 and 10,000 lb. per consignment, 36 per cent between 1000 and 3000 lb., and the rest, 37 per cent, between 1 and 1000 lb.

From this analysis, it seems logical to make two sizes of container: one of about 450 cu. ft. capacity, to carry from 3000 to 10,000 lb., which of necessity would be a flat-car or gondola-car container; and a smaller container of approximately 160-cu. ft. capacity, for use in box-cars to carry a load of 1000 to 3000 lb. These two sizes would take care of 63 per cent of the l.c.l. traffic; the remaining 37 per cent, or those shipments ranging in weight between 1 and 1000 lb., would have to be collected as at present and then loaded into containers by the railroads at their freight sheds, if any worthwhile benefits can be obtained from decreased transfer costs and by setting out a container at way stations instead of a box-car as at present.

Requirements To Be Met in Design

In design, containers should meet the following requirements:

(1) The container should be a simple box, sufficient in size and strength to hold and support the tonnage for which it is designed and to withstand the handling to which it will be subjected. Refinements and appurtenances can be added as their worth is proved in actual operation

(2) The containers should lend themselves to use by the highway and railway equipment now operated. To obtain the maximum economic benefits from container use, the necessity of using specially designed railroad and highway vehicles must be avoided; otherwise the excessive cost of this special equipment will in a large measure defeat the objects of container use. When their special use has become established and economies from the use of specially designed vehicles has been proved, it will be time to adopt special equipment

(3) For purposes of interchange among the railroads, the containers should be of a standard design. If the container is to come into general use, it is fundamental in the design that it shall be interchanged among all the railroads conducting the service. This means that containers must be designed to suit the majority of the gondola, flat and box-cars now in use by the railroads throughout the Country. No doubt special requirements of individual roads will necessitate special designs, but it is problematical whether these special containers ever will get off the rails of the road conducting the operation

(4) Provision should be made for handling the containers with cranes where cranes are available. They should also be constructed so that they can be moved on wheels at the terminals, but should not have this moving mechanism when in transit on the truck or railroad car. Crane handling at terminals where the traffic is sufficient to warrant the installation is the best method for both speed and economy. But the design should not prohibit the use of containers at places where the cost of crane installation would be prohibitive for the amount of work to be performed. Although wheels are of benefit at the terminals and warehouses, they are a decided detriment if they are operative while the container is in transit, as special holding devices then are required on the railroad cars and the highway trucks. For this reason the transfer device should be so designed that the container is "alive" when it is to be moved by itself and "dead" while in transit

The Field for Container Use

The field for railroad-container use, under the rates which the railroad can quote and still make a legitimate profit on the operation, comprises, as shown before, approximately 63 per cent of the present l.c.l. traffic. In addition to this, the container will, in effect, offer a smaller shipping unit than the box-car for the use of the public. It is only natural to expect that much freight which is now moving in minimum carload lots will be handled by the container operation. As the container offers its greatest proportionate saving on the comparatively short-haul freight movement, in which the terminal costs are many times the road-haul cost, it should be confined to relatively short-haul movements in the beginning of its operation and extended to the longer-haul traffic as it proves its economic value in the latter field.

The railways at present using containers are satisfied and enthusiastic about their operation. While the container is not by any means a remedy for all the troubles attendant on the movement of less-than-carload freight from its place of origin to its destination, it will facilitate the movement of most of the traffic.

Reduction in the total cost of transporting goods by containers is dependent upon ability to utilize the type of transportation which is economically preeminent in each field; that is, the truck in the terminal zone and the railroad for line haul. This is accomplished by offering a cheap means of transferring goods from one transportation facility to the other.

A New Type of Propeller

By Frederick Kurt Kirsten[1]

Spokane Aeronautic Meeting Paper *Illustrated with* Photographs and Drawings

The propeller described consists of a rotor disc from which a series of blades project at right angles to the surface of the disc. These blades are mounted so that their axes lie on an orbit concentric with the axis of the propeller rotor, and they rotate about their own axes at one-half the rate of the propeller. They are aligned so that each is in the most advantageous attitude with respect to the airstream for the production of a propulsive effort. The propulsive force is directed in such a way that all blades are effective during the complete revolution on the orbit.

The efficiency of the device as determined by a series of special tests is far superior to the efficiencies obtainable by screw-type propellers, according to the author, and the chief advantage of the use of this new propulsive device lies in the fact that its thrust can be directed along any desired line in the horizontal plane coincident with the rotor surface.

Application of the propeller to several branches of engineering service, to aeronautics, to marine vessels, to windmills and to ventilation appears possible. The simplest application suggests itself in connection with the propulsion and control of dirigible balloons.

SOME of the results of intensive research-work covering a period of approximately 5 years are presented herewith. This research was concentrated upon the development of a new type of propeller, shown in Fig. 1, which consists of a rotor disc from which a series of blades project at right angles to the surface of the disc. The blades are mounted so that they rotate about their own axes, which lie on an orbit concentric with the axis of the propeller rotor. The disc itself is coincident with the surface of the hull of the vessel on which the propeller is installed. The blades are mounted so that their leading and trailing edges are at all times perpendicular to the disc surface of the rotor. These blades rotate at one-half the speed of rotation of the propeller and are aligned in such a way that each blade is in the most advantageous attitude with respect to the airstream for the production of a propulsive effort. We have tried combinations of 2, 4, 8, 16 and 32 blades in operation. The alignment of the blades is such that their chords, if extended, will intersect in one point on the blade orbit. The propulsive force is directed in such a way that all blades are effective during the complete revolution on the orbit.

It will be noted from the view at the right of Fig. 1 that if the propeller rotates in a clockwise direction, the blades must turn about their own axes in a counter-clockwise direction. But the blades turn through an angle of only 180 deg. while the propeller turns through an angle of 360 deg.; that is, the rotative speed of the blades is one-half the rotative speed of the rotor of the propeller, as already stated.

Tracing the leading edge of a blade through one revotion of the propeller, it will be found that it becomes the trailing edge when reaching the initial position; in consequence, the blade cross-section must be conversely symmetrical to be equally effective in either direction.

Arrows at the right in Fig. 1 show the directions of forward and reverse thrusts of the rotor disc and of the blades. The full-line arrows indicate the direction of thrust and of rotation for the positions of the blades as shown. The dotted-line arrows and dotted lines show the position and direction of rotation for reverse thrust.

It is apparent from the arrows on the photograph that the blades on the upper half of the orbit move against the propeller airstream, and the fact that these blades produce a thrust in the same direction as those on the lower half of the orbit may appear as a mechanical paradox. However, when placed in a wind-tunnel and left idling in an airstream having a velocity of 30 m.p.h., this machine actually will rotate at such a speed that its blades travel on their orbit at a velocity of 32.5 m.p.h. This shows that the blades on the upper half of the orbit must overcome the drag of the blades on the lower half or that the most efficient part of the propeller is the upper half, and this is contrary to all expectation. While these tests were carried on, the propeller was absorbing sufficient energy from the airstream to overcome its internal resistance and to drive an electrical speed-indicator. This phenomenon is easily explained by theory.

The efficiency of the device, as determined by a series of careful tests, is far superior to the efficiencies obtainable by screw-type propellers and the chief advantage of the use of this new propulsive device lies in the fact that its thrust can be directed along any desired line in the horizontal plane coincident with the rotor surface.

An important finding was the high efficiency of more than 90 per cent. This prompted me to make a series of careful investigations involving various speeds of operation, various blade-forms, numbers of blades, blade sections, and variations in blade length, width and thickness, and also to investigate the effect of changing

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the setting of the blades with respect to the direction of the airstream in the wind-tunnel.

The propeller was also tested for its characteristics when operating as an airfoil; that is, when idling on its shaft in a windstream. The interaction between the windstream and the propeller is such that, under idling conditions, forces are set up in both the direction of the airstream and at right angles to it. The force in the direction of the airstream is the drag and the force normal to the airstream is the lift.

These definitions apply also to an airfoil placed in an airstream. While the lift force on an airfoil is almost directly proportional to the angle of inclination of the chord to the airstream over an angular range of approximately 15 deg. negative to 15 deg. positive, the lift of this propeller is almost directly proportional to the angle of the blades over more than twice that range. This is true at slips of from 20 per cent negative to 20 per cent positive, which is as far as investigations have been carried; but it appears that this is true for all operating slips. This is a very important discovery, the significance of which cannot as yet be estimated in its application to aeronautical problems.

Noiseless Operation

It also is evident that this propeller will be noiseless in operation. A two-bladed screw-propeller, operating at 1800 r.p.m., or 30 revolutions per sec., imparts 60 rhythmic impulses per second upon the airstream passing through it, thus producing a musical note. Each particle of air is impelled only once, which allows it to vibrate in unison with the particles in the same streamline. However, when the air passes through the new propeller, each particle of air receives two impulses, no matter how many blades are used. These impulses do not follow in rhythmic sequence since the path of the particle of air through the propeller is not commensurate in any simple ratio with the path of the blade on the orbit. No two adjoining streamlines in planes parallel to the disc of the rotor have paths of the same length through the propeller; hence the impulses cannot be rhythmic but must produce interference of nodes so as to render the operation of the propeller inaudible. This has been proved by many experiments.

[2] See University of Washington, Engineering Experiment Station, Bulletin No. 38.

Report of Performance Tests

Recently I completed a performance-test report of this propeller for the Board of Aeronautics of the Navy. The report consists of 269 pages of descriptive matter, test calculations and performance curves. First, the test set-up had to be designed and special apparatus developed, and considerable experience was necessary before the set-up yielded reliable readings. One of the most delicate pieces of apparatus developed was a set of automatic, electrically operated test-balances which will measure accurately and rapidly to a fineness of 0.01 gram. These balances were developed by my associate, B. F. Farquharson, instructor in aeronautics, who published his work in a bulletin[2]. The balances gave highly satisfactory service during a period of 1¼ years of almost continuous operation.

Possible Applications

This research was conducted with a definite practical objective in mind; that is, the application of the new propeller to several branches of engineering service; to aeronautics, to marine vessels, to windmills and to ventilation. It also promises excellent results when used as a flow-meter.

The simplest application suggests itself in connection

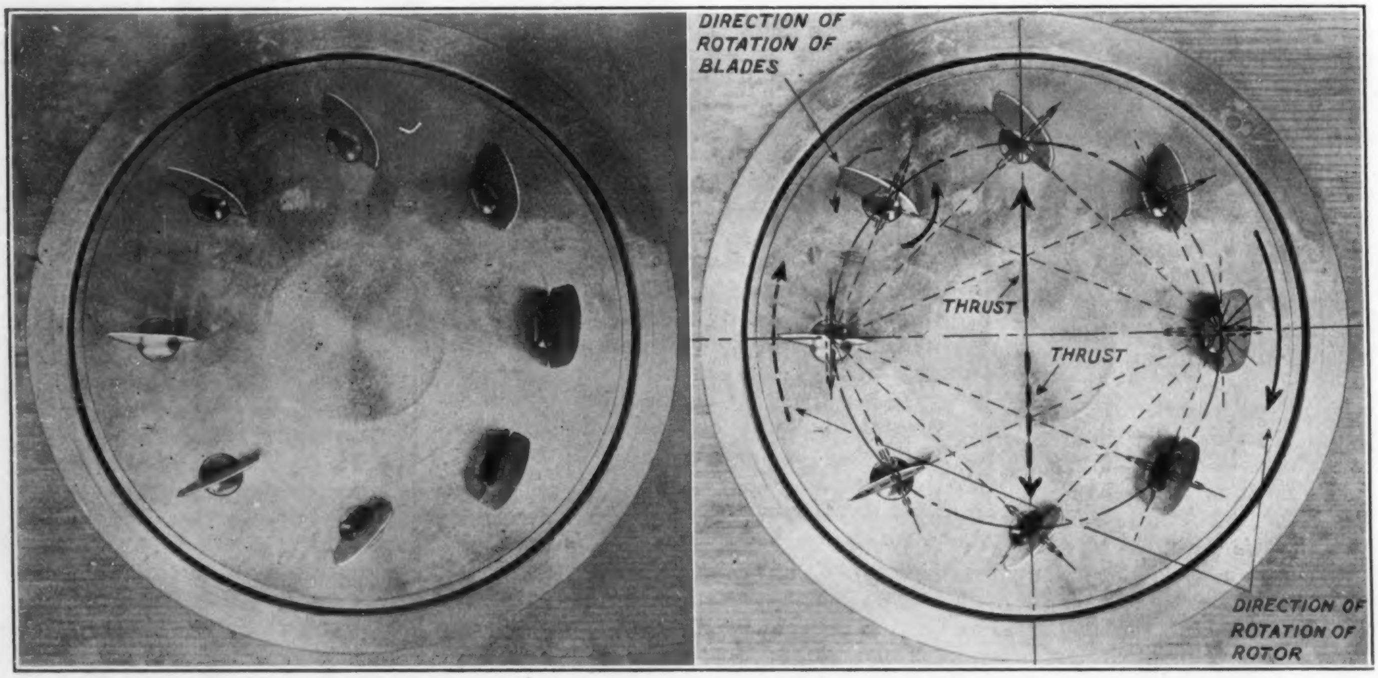


Fig. 1—Rotor-Disc Propeller with Rotating Blades

As Indicated at the Left, the Blades Project at Right Angles to the Surface of the Disc, Which Is Coincident with the Surface of the Hull of the Vessel That the Propeller Is To Drive, and Are Mounted So That They Rotate about Their Own Axes Which Lie on an Orbit Concentric with the Axis of the Propeller Rotor. As Shown at the Right, If the Propeller Rotates in a Clockwise Direction the Blades Must Turn about Their Axes in a Counter-Clockwise Direction. But the Blades Turn only Through an Angle of 180 Deg. While the Propeller Turns Through an Angle of 360 Deg. and the Rotative Speed of the Blades Is Therefore One-Half the Rotative Speed of the Rotor Disc. Directions of Forward and Reverse Thrusts of Rotor Disc and Blades Are Indicated

with the propulsion and control of dirigible balloons. Figs. 2 and 3 show a dirigible as it would appear if equipped with the new propellers. The cross-section of the balloon, as shown in Fig. 2, would be egg-shaped instead of circular. The propellers would be installed near the bottom on the slanting sides of the vessel and the driving engines located within the hull. Three pairs of propellers are shown distributed along the hull in Fig. 3, and one pair installed near the tail, the rotor discs being in horizontal planes. The pair of propellers located in the tail, as shown in the lower portion of Fig. 2, give horizontal control and eliminate the vertical rudder-surfaces. By operating the other propellers and differentially controlling their thrust directions, the horizontal rudders and fins, as well as ballast shifting, also can be eliminated.

It is interesting to note that vertical thrust-components can be made available in considerable amount without appreciably influencing the magnitude of the horizontal thrust. The advantage of being able to direct the propeller thrust along any line in the plane of the rotor disc will add considerably to the maneuverability of the dirigible, especially on landing, when the decreased speed of the vessel renders the rudder surfaces more or less ineffective.

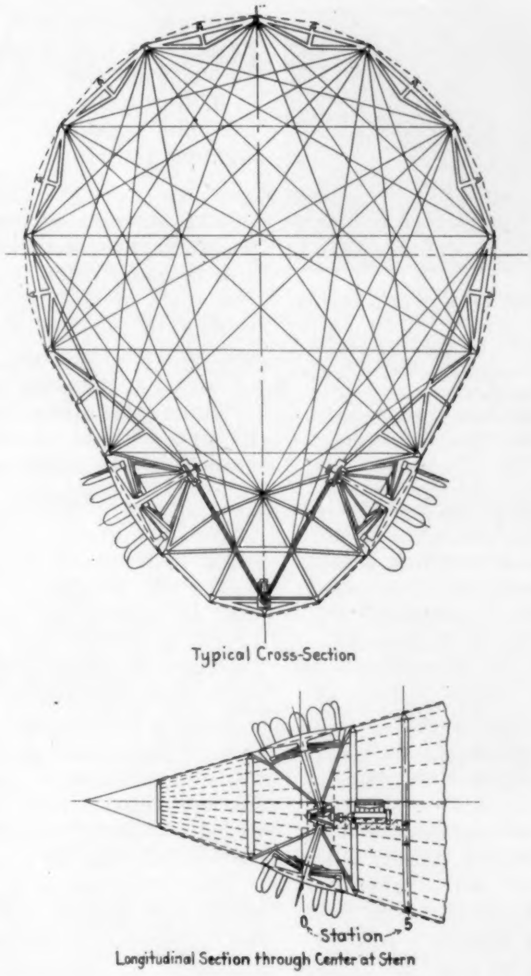


FIG. 2—APPLICATION OF THE ROTOR-DISC PROPELLER TO DIRIGIBLE BALLOONS

The Propeller Would in This Case Be Installed Near the Bottom of the Balloon on the Slanting Sides, as Shown in the Upper View, the Engines Being Located within the Hull. The Pair of Propellers Located in the Tail, as Shown in the Lower View, Give Horizontal Control and Eliminate the Vertical Rudder-Surfaces

Considering the forces acting on a dirigible, we find, first, the force of gravitation acting downward along a vertical line. This is balanced by an equal and opposite force; namely, buoyancy. A third force, which creates locomotion of the vessel, is furnished by the screw-type propellers in a fixed direction at right angles to the first two forces. Hence, neither buoyancy nor gravitation can be augmented directly by the propulsion system but are affected only indirectly by the locomotion of the vessel through rudders and elevators.

Rudder surfaces are effective in proportion to the square of the speed of a vessel and lose their effect when the vessel has to slow down for landing, just at a time when control is needed most urgently. Similarly, a large ocean liner must stop its powerful propulsion machinery and whistle for help when nearing the wharf. The airplane is similarly afflicted. It operates by virtue of two systems: the system of propulsion and the system of sustentation. The former supplies the locomotion by a horizontal thrust which is equal to the momentum of the rearwardly accelerated airstream; and the latter system, consisting of the wings, accelerates an airstream in a downward direction, the momentum of this airstream being equal to the weight of the machine. The

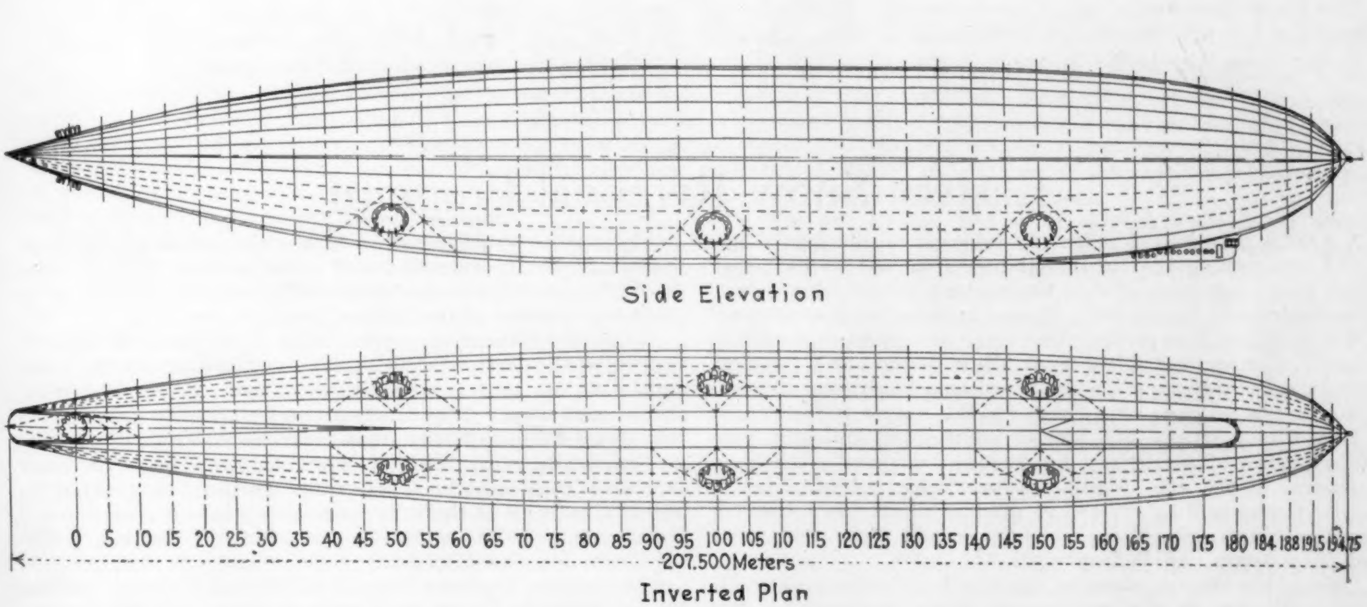


FIG. 3—LONGITUDINAL PLAN AND ELEVATION OF ROTOR-DISC-PROPELLER INSTALLATIONS ON A DIRIGIBLE

FIG. 4—EXPERIMENTAL MOTORBOAT EQUIPPED WITH ROTOR-DISC PROPELLER

Dynamic Control of the Boat, Which Has No Rudder, Is Afforded by the Propeller. The Boat Can Turn Around in Its Own Length and Can Be Reversed under Power from Full Speed Ahead to Full Speed Astern without Reversing the Rotation of the Propeller. The Inward "Bank" of the Boat When Making a Sharp Turn at Full Speed Is Evident

two systems operate at right angles to each other and there is no give-and-take between the two when in horizontal flight or when the airplane is attempting a landing. The new propeller will remedy some of these defects. A heavier-than-air machine equipped with these propellers has been designed and it is hoped that a model will be built and tested in the wind-tunnel in the near future. By replacing the static rudder and control surfaces by the dynamic action of this type of propeller placed in proper positions along the hull, difficulties of control on landing as well as difficulties of ballasting may be greatly reduced.

Fig. 4 shows an experimental boat equipped with a Kirsten propeller. It has no rudder but has dynamic control from the propeller. This boat can turn around in its own length and can be reversed under power from full speed ahead to full speed astern within a few seconds without reversing the direction of rotation of the propeller. The boat is shown making a sharp turn under full speed. The inward "bank" of the boat while turning is evident.

The propeller blades can be removed without dry-docking the ship by opening the rotor housing in the hull at a point above the load water-line, attaching a flexible wire to the end of the blade shank and removing a lock-nut which holds the blade in vertical alignment. The blade then drops out of the rotor and is hauled over the side of the vessel. A new blade is then attached to the wire, the blade is dropped over the side of the ship and pulled back into its former position, where it is again secured by the lock-nut. Eight blades can thus be removed and replaced by another set in 25 min.

The propeller operates without vibration, and one of its chief features is its stabilizing effect upon the hull against rolling.

FUTURE APPLICATIONS

The outcome of the application of this new propeller to aircraft is, naturally, problematical and its practical use in many fields is at present more or less visionary; but tests of the propeller described are sufficiently assuring to give me encouragement to carry on my research with the hope that a contribution to the success of aviation may ultimately be the reward.

There are other lines in which this propeller may be applied and as time progresses research will be undertaken to sound out its range of applicability.

UNIVERSITY OF WASHINGTON PLANS

We have at the University of Washington at present some fairly good equipment for aeronautical research work. W. E. Boeing, founder of the Boeing Airplane Co., donated to the university a wind-tunnel patterned after the old 4 x 4-ft. wind-tunnel of the Massachusetts Institute of Technology. With this tunnel we can generate a wind speed of 50 m.p.h.

Precise testing-equipment has been added during the last 10 years and more is being added each year. We are now planning to increase materially the curriculum for aeronautical work, but this depends upon the demand for it by the students and upon the amount of money that may be made available.

The Navy has been so kind as to allow us a great amount of obsolete equipment which will be shipped to the university in the near future. This includes three airplanes of different types, 12 engines of various makes, and aeronautical instruments, all of which are to be placed on display for the benefit of the students.

Inquiries have come from many students who wish to specialize in aeronautical engineering and it seems that recent events in aeronautics have given a great incentive for the youths now in our universities and colleges to learn something about this fascinating field of endeavor. We hope that we shall be able to give these students an opportunity to follow this new profession so that, 4 or 5 years hence, the demand for aeronautical engineers can be satisfied in some measure.

Eastern Snow-Removal Program

MORE than 33,125 miles of highways in the nine States comprising the North Atlantic area will be kept open and free from snow during the present winter, at a cost of approximately $2,400,000. States included in the area are Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, and Pennsylvania. The figures given are based on a 10-per cent increase in cost and mileage over those for the winter 1926-1927.

Over 1500 trucks, 500 tractor snow-plows and numerous other types of machinery are required to handle the snow removal in the nine States. Approximately 1000 miles of snow fences will be erected to prevent drifts from forming in the highways. New York State will build 700 miles of snow fence and Pennsylvania 235 miles.

Many populous centers in the North Atlantic area make the situation doubly serious, as some communities are almost entirely dependent upon food supplies shipped by motorcoaches from nearby cities. Thousands of children, especially in the suburban and rural sections, depend upon motorcoaches as a means of attending school, and this is an important factor in the demand for snow removal.

The day of hoarding supplies of food in homes to last the entire winter has passed. In its stead has arisen the modern situation of buying supplies from a merchant several times each week. This has presented a transportation problem for food distribution that must be met by open roads.

Practically every State is extending its mileage for snow removal each winter. The annual program is planned to cover almost all of the important systems, with counties and rural communities cooperating in clearing "feeders." The program for the 1927-1928 winter season is the greatest since the open highway became a National problem, and the North Atlantic States are leading the way.—From a statement by the American Automobile Association.

Production and Progress

THE claim is made in some quarters that real wages have not increased in all industries in correspondence with the calculated increase in productivity. That may be. The cost of living is not in manufactured goods alone. Furthermore, changes in the raw-material costs affect the prices of manufactures despite manufacturing efficiency; also, the gain in productivity is not uniform for all manufactures, and for many staple goods is below the average. And again, the spread between wholesale and retail prices is an important factor in living costs. It is largely a service charge, and service charges have undergone little reduction, because they consist mainly of wages. Service charges, including taxes, are a constantly increasing factor in the cost of living, particularly in urban communities.

This leads me to mention one more important consideration, which is that the figures for industrial gains do not represent final net gains in our industrial position. There are offsets which it is of the utmost importance to bear in mind. In certain respects the growth of population tends to increase the labor cost of supplying many of the common necessaries of life. We know that in this Country the original stores of natural wealth are rapidly being depleted. The fertility of the soil is scarcely maintained; the forests are being rapidly cut away, and our supplies of mineral wealth, of oil, of ores and of coal are being rapidly drawn upon. Since the more accessible and most cheaply worked are taken first, it follows that the tendency is to rising costs.

Over against these tendencies we have the influence of improvements in the methods of production and distribution. The net result of these two sets of influences determines whether society moves forward or backward. It is not, therefore, solely a question of how fast we shall advance; there is first of all the question of whether we shall be able to hold gains which thus far have been made.

Society is always in the position of a man rowing a boat up stream. There must be constant effort on his part if he is even to hold his own, and so as population increases there must be increasing command over the resources of nature, constant improvements in the arts and industries, to enable society even to hold its own. Unless we accomplish such improvements, unless we develop greater harmony and efficiency in industry, and leave to those who come after us an inheritance of knowledge and of industrial equipment greater than we received, we shall have merely exploited this Country and left our successors with a greater population to face harder conditions than we have known ourselves.

The people are always expecting that conditions will improve. They want the hours of labor shortened, they want a greater abundance of the comforts of life, they hope for better conditions for their children than they have had for themselves. These wants and aspirations are wholesome and helpful if they serve as a spur to intelligent efforts for their realization, but misdirected if they only stimulate impatience and disorder. The achievement of these conditions is the task of the industrial organization, and the efficiency of the organization is chiefly dependent upon good understanding and sincere cooperation among all the elements composing it. The responsibility for progress, for the advance of learning, and the increase of industrial productivity which renders social progress possible, does not rest upon a few. The common welfare is involved, and it is everybody's problem.—From an address by George E. Roberts, vice-president of the National City Bank, before the National Association of Manufacturers.

Scientific Analyses of Distribution

ASSISTING business in solving the present-day problems of distribution is one of the most important functions which now confront the economic service units of the Government. The big job before the Government is to work with business in considering the many vitally important problems of distribution efficiency and in attacking them with the more modern weapons of scientific analysis, so that maximum benefits may accrue to the consumer as well as to the producer and the distributor.

Unfortunately, efficient manufacturing has not had a counterpart in that other great phase of business which we call distribution. We have no yardstick by which we can measure progress in distribution as we can in manufacturing, because no fundamental census of the distributive agencies has been compiled. Incredible as it may seem, we are lacking almost entirely in any accurate comprehensive information as to the largest single item in our whole commercial activity, namely, the volume of wholesale or retail trade, or as to the character of the outlets through which various commodities are handled.

The experimental censuses of distribution in a dozen cities scattered throughout the United States, conducted by the Census Bureau last summer, represent the first official step in this direction. They have already revealed considerable information which will be of vital interest, not only to wholesalers and retailers, but to advertisers, shippers and the others engaged in facilitating more efficient distribution.

A more detailed study of the cost of distribution is an important line of attack. Admirable surveys in this field have already been made by some universities, trade associations and research agencies, but there is still unquestionably a woeful lack of knowledge regarding the various factors in the cost of distribution.

There are certain phases of market research in which the Government can properly take part and can supplement the work of private agencies in such a way as to make their efforts more effective. The Bureau of Foreign and Domestic Commerce is about to release the first of a series of regional commercial surveys which attempt to determine the basic commercial attributes, the factors affecting distribution, and the actual status of the buying power of the various economic areas of the Country. For this purpose, the Country has been divided into nine large regions, and the survey covering the five Southeastern States was available for distribution before the holidays. Those in the New England area and the Pacific Southwest are well under way, and it is hoped that Congress will authorize the completion of all nine of these surveys within the next three years.—From an address by Dr. Julius Klein, director of the Bureau of Foreign and Domestic Commerce, before the American Association of Advertising Agencies.

Rail-Car or Motorcoach—the Economic Field of Each

By H. F. Fritch[1] Transportation Meeting Paper

A RAILROAD has the right and the obligation to use the most efficient vehicle available to handle its traffic so long as it renders a reasonable service, regardless of whether the vehicle operates over the company's rails, over the highways or through the air.

The railroad was for many years the only means of rapidly transporting passengers and merchandise on land in volume. Simultaneous development of the internal-combustion engine and of the highways has changed this condition. The private automobile has revolutionized the travel habits of people in the last 15 years and more especially in the last 10 years. The diversion of large volumes of traffic from the railroad to the private automobile has forced the railroads to find cheaper means of caring for their traffic on lines where the volume of business has fallen off. It is economically unsound for a railroad to continue to operate with any other than the most efficient units available. To do so is not for the good of the railroad or of the community; for the railroad it means unnecessary operating expenses and for the public depleted service; and, eventually, the unnecessarily high operating cost will have to be paid by the public.

The internal-combustion engine has made possible two new units for handling the smaller volumes of traffic: the motorcoach for highway use and the rail-car for use on the railroad right-of-way. The contemporaneous development of these two vehicles results in interesting problems to determine which of the two can be used in each particular instance to the best advantage. Each has a field and these fields seem to overlap. Each case under investigation must be decided on its own facts, for it is impossible to lay down a hard and fast rule or formula by which all cases can be decided.

For the purposes of this paper, only the transportation of passengers and of the classes of goods ordinarily transported on passenger trains will be considered. These goods are mail, newspapers, baggage, express shipments and milk. No consideration is here given to the motor-truck, which may, in some instances, be a desirable unit to use along with the motorcoach in substitute services to care for freight. I shall point out some of the factors that we have found in our experience on the Boston & Maine Railroad which should be considered in determining whether an operation should be converted to rail-car or motorcoach.

Must Recognize Changed Travel Habits

One of the most important things in studying this problem is to be forward-looking and to recognize that the automobile has changed travel habits, that it has an appeal to personal convenience which is very powerful, and that diminished service on branch lines facing such competition is very likely to result in further depletion of revenue. Furthermore, the advantages and the limitations of both the rail-car and the motorcoach must be squarely recognized and their effect not only upon operating costs but upon traffic promotion must be reckoned with.

One of the fundamentals to be determined is whether the continuation of a rail line is necessary or desirable for other traffic independently of the passenger requirements. If the passenger service alone must bear the burden of supporting the rail line where the traffic is light, the motorcoach acquires a considerable advantage over the rail-car, as it may become possible to dispense with the privately supported rail line and use the publicly supported highway. On the other hand, if the maintenance of a rail line is desirable for the operation of freight service, the use of a public highway as compared with the private way is of no great importance and the two vehicles must be compared on a cost basis in which maintenance of or investment in way is disregarded.

It has been argued that the operation of motorcoaches in place of rail service would endanger the continuance of a rail line and hasten the day of its abandonment. This is not sound reasoning if there is any economic justification for the existence of the rail line. If, as usually is the case, there is a fairly substantial freight business on a branch line and a light, unprofitable passenger business, the reduction of the passenger loss as a result of transferring the passenger service to the highway would lessen rather than increase the danger of abandonment of the rail line.

Highway Conditions Have Important Bearing

Highways in the territory must be studied with respect to both their layout with reference to the communities to be served and their character and capacity. Sometimes the communities can be served better by highway than by rail because of the closer proximity of the highway or the ability to detour a motorcoach through the settled districts, whereas the path of the railroad is expensive to change and is more limited as to curves and grades.

The character of the highway surface and its foundation is especially important in territory where winter conditions are severe. The improvement of highways is one of the most remarkable developments of our time of great accomplishments. During the last few years great progress has been made in snow removal. It has been demonstrated that much more can be done along this line than was dreamed of a few years ago and that the effect on the highway surface is beneficial, rather than harmful as had been predicted. While this opening of the highways in winter has made it possible to operate motorcoaches the year round in New England, and I suppose elsewhere, it has deprived our transportation lines of substantial amounts of revenue by mak-

[1] Passenger traffic manager, Boston & Maine Railroad; president, Boston & Maine Transportation Co., Boston.

ing it possible for the private automobile to stay in service through the winter.

Motorcoach and Rail-Car Development

Consideration should be given to the state of development of the motorcoach and the rail-car, having in mind its effect on obsolescence, on cost of maintenance and operation, and on reliability of performance.

The motorcoach for general highway use is a comparatively recent development. Large numbers of them are meeting severe operating conditions very well, but I feel that they have not yet reached the same high development as has the private automobile. Rail-cars were being produced before the motorcoach was being built for general highway use, but the production of the former practically ceased during the World War, only to be resumed with increased activity since its close. The real necessity for such a unit and the development of the gas-electric vehicle with throttle control of speed have been important factors in bringing the rail-car into prominence again. Great progress has been made in the last 4 or 5 years but I would hesitate to say that design has yet become stabilized. It seems to me that the tendency in rail-car design since the motorcoach has come into the field is toward larger and more powerful units than those first produced after its renaissance. Neither vehicle has finished its period of development, but good serviceable units of each kind are being produced and operated.

It is economically unsound for a railroad to continue to operate with other than the most efficient units available.

The internal-combustion engine has made possible two new units for handling the smaller volumes of traffic: the motorcoach for highway use and the rail-car for use on the railroad right-of-way.

The contemporaneous development of these two vehicles results in interesting problems to determine which can be used in each particular instance to best advantage.

One of the most important things is to be forward-looking and to recognize that the automobile has changed travel habits.

If the passenger service alone must bear the burden of supporting the rail line where the traffic is light, the motorcoach acquires a considerable advantage, as it can use the publicly supported highway.

If maintenance of the rail line is desirable for the operation of freight service, the rail-car and the motorcoach must be compared on a cost basis in which maintenance of or investment in way is disregarded.

The tendency in rail-car design since the motorcoach has come into the field is toward larger and more powerful units.

The final test in studying any case is the cost of rendering the service with steam equipment, rail-car or motorcoach. The motorcoach has a big advantage over the rail-car in wage costs.

Legal Restrictions Limit Motorcoach Capacity

The customary maximum capacity of single-deck motorcoaches today is 29 passengers. The capacity is limited to about this number in many States by legal limitation of length. With a compartment in the rear having 19 sq. ft. of floor area for baggage, mail or express, the seating capacity becomes 24, with 5 supplementary taxicab-type folding seats in the baggage section.

Rail-car capacity is not subject to legislative regulation but is controlled only by restrictions dictated by good engineering and operating practice. Some rail-cars have a capacity as low as 25 to 30 passengers. Others, having an over-all length of 73 ft., provide accommodation for as many as 86 passengers, or a space 57 ft. long for baggage or the like. Trailer cars up to about 73 ft. in length and having seats for 90 passengers, if there is no baggage space, are being operated. Two-car motor-rail-car trains in which the space is divided between passengers, mail and baggage as the necessities of the particular operation require, are now being operated commonly.

Possibilities of Redistributing Traffic

In studying any specific case, the possibility of redistributing traffic between other services available should first be gone into carefully. It is sometimes possible to rearrange traffic, having in mind not only the passenger service but the freight service available, so that trips that at first seem to be beyond the range of rail-car or motorcoach capacity become possibilities for such substitution. Newspapers, express goods and milk can sometimes be handled properly by other service without inconvenience to the public. These commodities can be transported much more readily on a rail-car than on a motorcoach. Usually it is difficult to take care of much more than first-class mail and some baggage or newspapers on a motorcoach. The Boston & Maine Transportation Co. has in service motorcoaches having a baggage compartment in the rear capable of carrying six medium-size trunks or 30 sacks of mail. Their capacity has been found ample in the services in which they are used. Then, too, it has been found practical in some instances to reroute some of these commodities in such a way that a reasonable service is retained but the loads are lightened so that they can be moved by rail-car or motorcoach. It has been surprising to find the number of trips, originally beyond the range of capacity of the motorcoach or the rail-car, that can be considered for substitute vehicles after such rerouting or transferring.

The final test in studying any case is the cost of rendering the service with steam equipment, rail-car or motorcoach. Our observation of rail-car costs obtained from other companies is that they extend over a range so wide as to be very disconcerting. It is difficult to obtain figures made up in a uniform way, and the costs vary greatly with the type of service and more with the length of run. Motorcoach costs seem to vary less among carriers. We now find that the only satisfactory way for us to analyze each problem is to use costs derived from our own experience. On account of its importance and its wide variation in different cases, we attempt to estimate the labor cost for the exact runs involved; and we do the same with respect to interest and depreciation. Fuel and maintenance are figured on a basis of cost per mile.

Operating Cost Is the Final Test

The motorcoach has a big advantage over the rail-car in wage costs. It is operated by one man, who receives a daily wage of about $5.00, whereas a rail-car has a crew of at least two men, whose minimum daily wages amount to $14.04, and frequently has a crew of three men, whose

combined wages amount to $19.70 daily. Furthermore, the restrictions as to hours and mileage of the rail-car crew frequently increase these minimum figures. These differences are very important where the volume of traffic is within the capacity of the motorcoach.

Volume of Traffic Determines Choice

On the Boston & Maine Railroad, after passing through a transition period, the volume of traffic to be handled has now come to determine largely whether a rail-car or a motorcoach will be used in any case of substitution. The first experience of this road with these units was on a branch line of very light traffic-density. A small motor rail-car was substituted for steam service and the operating expenses were reduced substantially. The mileage, however, was very low, and this resulted in the cost still being excessive. This rail-car was then replaced with a motorcoach and the cost was still further reduced. An interesting development has occurred since then. The distance from the town at the end of the branch line to the principal adjacent city by motorcoach line following the branch line of the railroad and by main-line railroad is 13 miles, whereas the main-highway distance is only 8 miles. The substitute motorcoach still furnishes some service parallel with the branch line but its principal activity is in carrying passengers over the short route to the neighboring city. This is, of course, an improvement in service to the community.

The Boston & Maine Railroad now has 24 rail-cars in operation. Its subsidiary, the Boston & Maine Transportation Co., has 72 motorcoaches, of which 22 may be said to be operating in substitution for rail service. On the other hand, it should be pointed out that some rail-car mileage is being operated, not in substitution for steam rail service, but in addition to the former steam service in an effort to attract business by increasing the frequency of service. This type of rail-car service is being operated on main lines and experience seems to indicate that it is worthwhile. In one instance the service on a branch line has been increased with rail-car operation, compared with the steam-train schedule, after some experimenting was done with motorcoaches. Steam rail service was curtailed and supplemented by motorcoach trips, the total number of trips being increased. Later, when a rail-car became available, it was found more efficient to provide all the service by rail-car instead of part by steam train and part by motorcoach.

On another line 96 miles in length, between Worcester, Mass., and Concord, N. H., all the rail service is now provided by rail-car units. The arrangement of trips with a minimum number of units made impossible one main-line connection that is important for mail and passengers for a part of the line, so a motorcoach was used to cover this deficiency.

Intrastate motorcoach operations are very thoroughly regulated in New England. This is as it should be, but in some instances the Boston & Maine Railroad has been unable to convince those having the licensing power that they should make substitutions of motorcoaches for rail service where the railroad has felt it desirable. This has retarded the use of motorcoaches to their full advantage. On the other hand, the substitution of rail-cars for steam service lies entirely with the railroad management, and the Boston & Maine Railroad today is operating rail-cars to substantially the greatest possible extent, as it sees the problem, having available only one-car and two-car rail units. It is now studying the possibilities of heavier units capable of operating as three-car trains all or part of the time.

Typical Rail-Car and Motorcoach Operations

Some of the typical rail-car and motorcoach operations on the railroad will be outlined briefly. Rail-cars are now being operated at the rate of 970,000 train-miles per year. The Worcester-to-Concord run referred to previously is an example of the most common use of these units. It is an out-and-out substitution of rail-car units for steam trains, made because the volume of traffic could be handled by the rail-car. This operation is a 100-per cent change-over, while on other lines only part of the service has been changed.

On a 21-mile line between Plymouth and Lincoln, N. H., the two steam trips were changed over to rail-car trips and, because of the less expensive operation, a third trip was added.

Main-line service between Boston and Lawrence, 26 miles, was increased during the normal hours and two of the trips were made by rail-car with a very short turn-around time.

Train service between Boston and Portland was speeded up considerably, in part by eliminating stops of through trains. It was desirable to serve some of the intermediate places and to feed to and from the express train at its midway stop. The rail-car, on account of its economy of operation, made such a service feasible.

A surburban service is operated between Northampton and Springfield, Mass., a distance of 17 miles. There is a demand for a frequent service but the traffic is not heavy. It could be taken care of reasonably at least in part by motorcoaches, but a competitive condition with an electric-railway company makes it impracticable to obtain licenses to operate motorcoaches, so a 73-ft. rail-car that makes five round trips a day is being used.

Motorcoaches covering 1,500,000 miles per year are being operated by the Boston & Maine Transportation Co. A substantial part of the route mileage parallels the railroad in competition with independent motorcoaches operating without licenses on interstate routes. Passengers are traveling on them because of the lower rates and the desire to use a motorcoach. Operation on the highway by the railroad company makes it possible to compete for these passengers and to meet rate cuts without changing the rate structure of the railroad.

A motorcoach line is operated for a distance of 13 miles between Franklin and Bristol, N. H., in replacement of all rail passenger-service except that express is handled in freight service. More frequent service is furnished by motorcoach than was provided by rail, and connections are made with main-line trains. This operation is in sparsely settled territory where the traffic is light and the rail losses were considerable. The operation of a rail-car would be an extravagance. Passengers and mail are delivered right in the center of Bristol instead of at the foot of a long, steep hill; and at Franklin the school children are taken directly to the school. Winter conditions are severe and the highway never had been kept open until the transportation company bought a tractor to demonstrate that it could be done. It is in this type of operation to reduce rail operating-losses that the motorcoach probably can be of greatest benefit to the railroad.

Between Northampton and Greenfield, Mass., 19 miles, a motorcoach line replaces some steam-train service and

some stops by other trains which have been speeded up.

An independent electric-railway line connecting a beach with the railroad at Hampton, N. H., failed because of lack of business, so the Boston & Maine Transportation Co. started a motorcoach line as a feeder to the railroad. This line falls just short of earning its full operating cost, but it is a worthwhile operation, as it encourages people to travel by rail rather than by automobile. The railroad must do such things wherever it can.

Both the motorcoach and the rail-car are useful tools to employ in keeping the railroads on a sound operating basis; they provide a means of furnishing organized transportation to communities that otherwise would cease to have it and a better service in many instances than would be possible with more expensive units.

THE DISCUSSION

E. W. WEAVER[2]:—Mr. Fritch's company has had the experience of operating the different types of equipment and undoubtedly is doing as well as, or better than, anyone else in using the proper tool for each service. The average load carried has been stated at this meeting to be about 14 passengers per car. Has Mr. Fritch obtained any data on that in his operations? Someone has said that nothing is so fleeting in value as an empty motorcoach seat; that is, one of the makers of the smaller type of equipment has been using that phrase in his publicity. The motorcoach is, of course, much lighter than any rail-car, and in many ways it does not provide the same class of service; for instance, it has individual seats and the passenger expects to use only one seat. In rail-car work, particularly if there are only 14 passengers in a car, the ordinary person is prone to spread out and use about four seats.

CHAIRMAN H. C. CROWELL[3]:—I should like to caution everybody about the use of average figures. Fourteen passengers per car is the average for the Country as a whole but may not apply to any one railroad, and certainly would not apply to any one branch of one railroad. We may find branches on which the average load is as low as five or six; in fact, I have in mind one branch on which investigation indicated that there were more men in the crew than there were passengers.

CANNOT USE SMALL MOTORCOACHES

H. F. FRITCH:—I do not know what the average number of passengers per railroad coach is on the Boston & Maine Railroad. I wish I did. I cannot imagine that it is much greater than the average for the Country, but most of the steam trains that have been replaced by either rail-cars or motorcoaches have been trains of two or three cars; that is, a passenger coach, perhaps a smoking car, and a car for mail, express or baggage, or for a combination of these classes of shipment; or, in some cases, a two-car train consisting of a combination coach and smoker and a coach for utility purposes, such as baggage, mail and express.

Even so, we have found that the opportunity for using single rail-cars is rather limited. That sounds rather queer in connection with a 14-passenger average, but it is a fact, and most of our operations today are of two-car units for at least part of the day's work. We have operations in which we run single cars and then, for certain parts of the day, couple on a trailer.

We have some motorcoaches that have a seating capacity as low as 21. We have none that seat less than that number, nor would we have use for any except in one or two very special operations which are not substitutions for steam service.

Our experience is that the motorcoach generally ties in at a definite time at some junction point with the main-line train operation, which service is different from the independent operation of motorcoaches where the service is improved perhaps and the traffic is built up by more frequent service. We have some one definite time at which we tie in the motorcoach with another operation; in most instances the people want to travel at that particular time and not at some intermediate time with no main-line train connection. As a result, we find that the 29-passenger motorcoach is the smallest type we can use to advantage in most cases. It has a section for baggage in the rear where there are also folding taxicab-type seats, and these are occupied very frequently when that section is not used for mail or baggage.

TWO-AND-TWO SEATING ARRANGEMENT BEST

I think it is a fact, which I will not undertake to explain any more than I will try to explain why people want to ride in motorcoaches on long hauls, that passengers seem much more willing to accommodate themselves to limited space in a motorcoach than in a rail-car or steam coach. The customary motorcoach seat, although very comfortable, soft and well upholstered, usually gives the passenger much less room than he would have in a steam railroad car. When we started using motorcoaches 3 years ago we bought special seating equipment that would seat only 20 persons in a 29-passenger parlor-car. We had a two-and-one seating arrangement specially built in place of the conventional two-and-two arrangement. But a year ago, at considerable expense, we scrapped those seats and put in double seats in pairs because, after going into the question thoroughly, we were convinced that the extra refinement in comfort did not earn us a nickel; in fact, we found that the coaches with the two-and-one seating had to be double-headed, whereas, with the standard seating arrangement we avoid the double-header.

I think we have come to the point with our rail-cars where we shall improve the comfort of the seats. Most of the rail-cars in use today have the conventional two-and-three seating arrangement. That may be all right on some branch lines where there is no real opportunity to promote traffic but where at times there is a peak load; but on lines where it is desired to give a real service, especially such service as we are operating, some of which is supplementary mid-day service, and where the attractiveness of the ride is a factor, I believe the two-and-three arrangement is a mistake and that a two-and-two arrangement should be adopted and a very comfortable seat provided.

CHAIRMAN CROWELL:—I think that all of us railroad men who have had experience agree with Mr. Fritch that the people have been educated to having a seat on the steam train, and a comfortable seat. As has been said, they will spread out and take as much space as two people, and even space that should be occupied by four passengers. On the other hand, we have been taught to crowd into automobiles, five, six, seven and perhaps ten persons; we are used to cramped conditions when riding

[2] M.S.A.E.—Chief engineer of the automotive department, George T. Trundle, Jr., Engineering Co., Cleveland.

[3] Assistant to chief engineer, Pennsylvania Railroad, Philadelphia.

on rubber, and it seems to me that although the motorcoach with its two-and-two seating may be a little cramped it is sufficiently comfortable.

For the seating on railroad coaches, I think the experience of all the railroad men is that the three-and-two arrangement generally is a mistake; passengers do not like it.

COULD OPERATE TRUCKS WITH MOTORCOACH SERVICE

F. C. HORNER[4]:—As I recall, Mr. Fritch said that a quantity of mail, express and baggage has to be dealt with, although he did not say how much, and that it was not usualy advisable to put it on a motorcoach. Has he attempted to supplement his motorcoach service with high-speed truck service to take care of a limited amount of baggage, express and mail?

MR. FRITCH:—We have not used a truck in any service yet. We have one operation for which we are trying to get permission from the State authorities to operate a motorcoach in substitution of steam service for one round trip, and where on Sundays we would like to use a truck. If we gain permission to operate the motorcoach, we shall use a truck to handle the Sunday newspapers.

On the Bristol branch where we have substitution for 100 per cent of the passenger trips, the express shipments are still handled on the mixed train, although we do handle some special rush shipments on the motorcoach, but not in any large quantity.

MR. HORNER:—Do you believe it would be economical and advantageous to test truck operation in this field if it has not been done by some other railroad?

MR. FRITCH:—I believe it has a very proper field; there is no doubt about it. We are using trucks today in connection with our local freight handling, but not on any route where we are also running a motorcoach. I believe there is no reason why the truck could not be fitted in very well with a motorcoach service to take care of the merchandise and baggage.

D. C. HERSHBERGER[5]:—I have gathered a few figures on cost per passenger-mile for steam train gas-electric rail-car, and motorcoach service. The published costs per train-mile on one railroad are $1.58 for the steam train, 72 cents for the gas-electric, and 28.9 cents for the motorcoach. Reduced to the passenger-mile cost, on the basis of an average load of 50 per cent of the seating capacity, it is interesting to note that the rail-car shows the lowest of all, being about 1 cent per passenger-mile. The motorcoach cost is about 1.9 cents and the steam-train cost about 16 cents.

Another point mentioned this morning was the salvage value of the equipment released. I think something ought to be considered in connection with that. The railroads are always endeavoring to bring their equipment up to a higher state of repair and to adopt higher-class equipment, so there is a certain quantity of obsolete equipment that can be scrapped. It is often possible to transfer to other parts of the system some of the better equipment released so that the entire value of the equipment released is not lost. In some instances, a fair salvage value can be obtained for the obsolete equipment.

CHAIRMAN CROWELL:—I think conditions are not exactly as Mr. Hershberger thinks they are as regards the use of light replaced equipment; at least, they are not in our part of the Country. We have a tremendous surplus of motive power and coaches available for branch-line use, and the number of branches that are being operated is becoming smaller and smaller all the time. I know Mr. Fritch's road has done away with a tremendous number of branches. The result is that we have a great surplus of light motive power and old and possibly antiquated passenger-coaches.

In estimating the cost of giving the existing steam rail service, a person should not deceive himself by charging that service with interest on a high valuation or with depreciation at a high rate; the value is little more than the scrap value and the depreciation probably has been absorbed almost 100 per cent, so there is little to be charged against the steam operation so far as interest and depreciation are concerned, for the reason that if replaced by rail-cars there is usually no place to put that light equipment.

[4] M.S.A.E.—Assistant to vice-president, General Motors Corporation, New York City.
[5] Assistant gasoline-electric traction engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

By-Pass Roads

THE adoption of by-pass roads should be made compulsory. The argument that trade is carried away from the town is obviously foolish. If the trade exists it is because there is a customer, and the customer must go to town to satisfy his needs. The through traveler has as much right to consideration as the local draper or baker.

In designing by-passes, more thought should be given to the approach at either end. Very often a splendid opportunity arises for dispensing with a dangerous corner or cross road, but too often that opportunity is neglected and a cross road is deliberately engineered. No by-pass should be approved until the possibilities of a second have been thoroughly examined and, if possible, the second should be planned at the same time even though it is not constructed. By this means, an orderly town will spring up around a disorderly center, and eventually there will be sufficient through roads to distribute the traffic to such an extent that further costly by-passing will be unnecessary, for it must be remembered that each succeeding by-pass is likely to be half as long again as the last, and proportionately more costly.—Major R. A. B. Smith, in a paper presented at the World Motor Transport Congress.

A Motor-Vehicle for House-to-House Deliveries

By LEE OLDFIELD[1]

DAYTON SECTION PAPER *Illustrated with* DRAWINGS AND PHOTOGRAPHS

ONE field of highway transportation service that the motor-vehicle has not heretofore successfully invaded is house-to-house delivery, especially of milk. The short distances traveled between stops, the relatively long waits between vehicle movements, and the intelligence of the horse which makes it unnecessary for the driver to enter the vehicle and handle the reins as he proceeds from house to house, give the single-horse-and-wagon unit a low operating cost that is very difficult to meet with a motor-vehicle.

The increasing difficulty of obtaining adequate stable facilities near the center of a delivery area in any city of considerable size is, however, bringing about a change in conditions that is forcing operators to adopt motorized equipment for this class of work.

It is essential, nevertheless, that a motor-vehicle that will be readily acceptable for this service and therefore a profitable manufacturing undertaking shall be as convenient to use and as economical to operate and maintain as the single horse and wagon.

This is the problem to which the author and his business associates have addressed themselves for a period of 14 years, and on which they have concentrated their efforts intensively for the last 4 years. Defeat had to be acknowledged for a time but, as a result of long investigation among operators and the collection of a mass of data, the design herein shown and described was worked out eventually. It is novel in most respects yet does not embrace radical ideas or unproved engineering principles.

It has a load capacity of one and two-thirds times its weight, a maximum speed with full load of 15 m.p.h., consumes 1 qt. of gasoline per hr. and 1 qt. of engine oil per week in normal operation, occupies only 50 sq. ft. of floor space, turns in a 30-ft.-wide street, is easy to maneuver in traffic and to park at the curb, has the minimum of unsprung weight, and has a unit powerplant and transmission that can be removed, together with the rear wheels, easily and quickly without entering the body or disturbing the load. This last feature simplifies service and assures good service work under favorable conditions in the shop. The minimum of interchangeable reserve power-units suffices for the entire fleet.

Simplified control features save the time of the driver, who stands as he manipulates the steering-wheel, clutch, gearshift lever and brakes. Enamel finish outside and inside the body, ample drains, and protection of the mechanism against water facilitate quick washing with a hose.

IT is intended that this paper shall be descriptive of the Pak-Age-Car, the circumstances which brought about its design and development, the reasons for the departure from conventional motor-truck practice in its design, and its place in the field of automotive transport.

The present design has developed from an idea worked on in connection with the design of a cyclecar in 1913, at which time it was proposed that a vehicle weighing about 1000 lb. and fitted with a 74-cu.-in. engine should carry a useful load of 500 lb. While working up this early design it was found that the 500-lb. load-factor did not have the value we had attributed to it, and the market for a vehicle of this capacity did not seem great enough to justify the sort of organization we proposed to promote. Many other factors also contributed to the abandonment of the original plan. One was our inability to make any really satisfactory reply to the prospective buyer who would ask how the vehicle would meet the driver around the corner or in the next alley as does the horse and wagon that we proposed to displace. This question stopped us then and we do not answer it directly even today, except by showing clearly the relative unimportance of this factor as compared with the many others involved in any comprehensive analysis of the transportation systems into which the Pak-Age-Car can be fitted advantageously. Under certain conditions which permit taking advantage of the intelligence of the animal, the horse-drawn equipment can and does serve the purpose better than any motorized equipment available.

Another factor of considerable importance was my lack of experience and that of my associates, as evidenced by our disposition to build what we conceived to be the proper vehicle for the purpose regardless of the sales resistance such a vehicle would meet.

Having determined that the 500-lb-capacity vehicle would not find a satisfactory market, we set out to discover what capacity and type of vehicle we might develop that would find a market which would be large enough to justify an organization that could operate profitably and yet be too small to excite the larger manufacturers. There seem to us to be several such possibilities and we have chosen the single-horse-drawn-wagon market for a number of reasons.

In developing the present design we have considered and abandoned, temporarily at least, such features as air-cooling, front-wheel drive, friction drive, and gas-electric drive; and the details that differ radically from standard practice have been accepted finally for production only after many interviews with prospective buyers and users have indicated that these features are acceptable to them. Certain other features which we greatly wished to use have been laid on the shelf for the single reason that the prospective buyer was not disposed to accept such details at this time.

[1] M.S.A.E.—Consulting engineer, in charge of design and development, Package Car Corporation, Chicago.

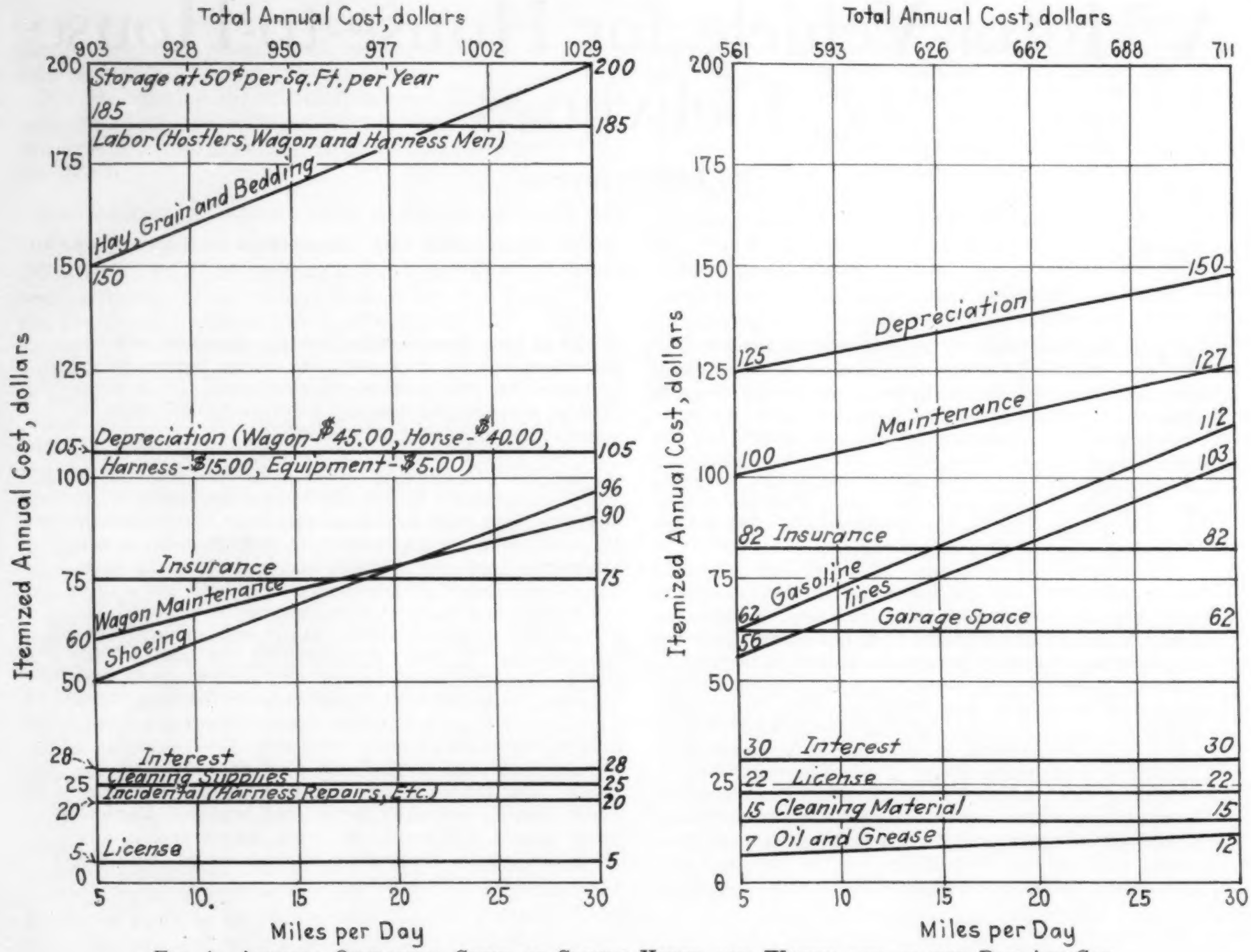


FIG. 1—ANNUAL OPERATING COSTS OF SINGLE HORSE AND WAGON AND OF THE PAK-AGE-CAR

Figures Shown in the Chart at the Left Are Minimum Averages Obtained from Horse-Drawn-Wagon Operation in Various Parts of the Country. Those in the Chart at the Right Are Based on More than 2 Years' Actual Delivery Experience with Experimental Motor-Vehicles. Both Charts Are Carried Out to a Daily Mileage of 30, Although the Average Day's Mileage for a Horse and Wagon in the Milk Business Is Approximately 10. Figures at the Top of the Chart Are Totals of the Items Below. Fixed Costs are Indicated by the Horizontal Lines and Variable Costs by the Upwardly Inclined Lines. Savings Shown for the Motor Wagon Indicate That It Will Pay for Itself in 3 Years on a Basis of 10 Miles' Operation per Day

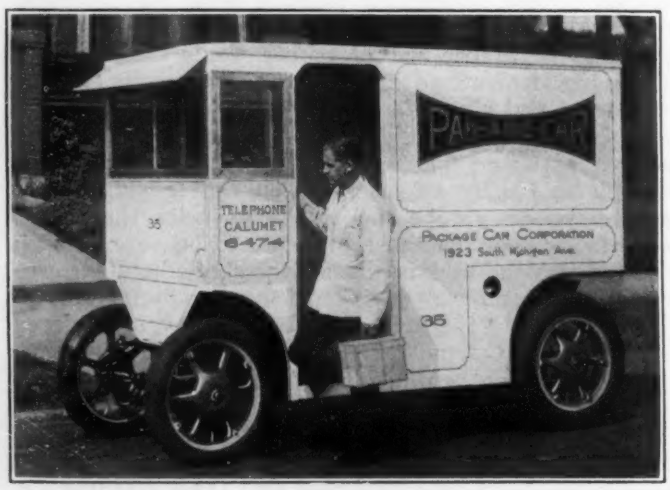


FIG. 2—LIGHT HOUSE-TO-HOUSE DELIVERY VEHICLE

Designed Especially for Milk Delivery, This Saves Time of the Driver, Who Stands To Operate the Controls. It Weighs 1800 Lb. and Carries a Useful Load of 3000 Lb.; Has a Maximum Speed of 15 M.P.H. with Full Load; Has an Over-All Length of 123½ In.; and Can Turn in a 30-Ft. Street

Temporary defeat was acknowledged in the fall of 1914, and we did not again attack the problem seriously until the fall of 1923, although the proposition was entirely ignored for only short intervals in that period. We were at all times on the lookout for any information that would have a bearing on it, continually interviewed operators of horse-drawn equipment, and collected a great variety of data relating to their problems. Our final successful effort to put the idea into concrete form resulted from the realization that these operators are now faced with new conditions and problems, practically all of which were brought by the automobile.

The most important of these new factors, from our standpoint as well as that of the operator, is the shortage of stable facilities. Until within recent years it was easy for an operator to increase his stable facilities to take care of increases in equipment, but today it is far from simple for the operator of horse-drawn vehicles to add to such equipment, which must be stabled approximately in the center of the territory it is to serve if it is to be operated economically. In most cases this necessitates having a stable in a residential dis-

trict, and this, it will be appreciated at once, is not a simple matter. Almost all city dwellers are motor-minded today but they usually oppose the granting of permits for the erection of garages in residential areas, and the issuance of a permit for the construction of even the most modern type of stable in such a zone is almost impossible in any important city in the Country today. Long and costly legal actions have followed the issuance of such permits in many cities in recent years, and these experiences, together with the fact that all departments of the business of these same operators are motorized except those served by the single-horse wagon, have brought about a state of public mind that is at least inquisitive. Many such operators are using motorized equipment that is more expensive to operate and less satisfactory than horses solely because of this stable problem.

I shall now define more clearly the field we have singled out. Our investigations have always indicated that the single-horse wagon unit was operating at greater efficiency, considering load, mileage, stops and costs, in the milk industry than in any of the other industries investigated. We have therefore concentrated our efforts on this field and think it is obvious

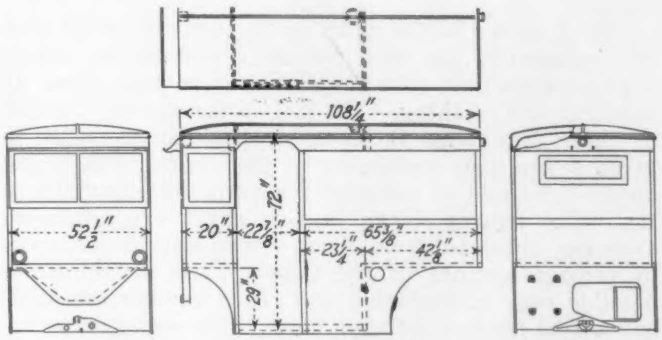


Fig. 3—Elevations and Half Floor-Plan of Body

The Body Has a Steel Frame to Which Are Attached Metal-Veneer Panels 6 Ft. Deep on the Sides. The Side Panels, with Stiffening Members at the Bottom, Make It Possible To Dispense with a Chassis Frame, and the Body Is Therefore Unusually Rigid

that, if the new vehicle can compete successfully with the single-horse milk wagon on the favorable basis indicated by the accompanying charts, it will be even more successful and economical in other industries in which the delivery problems are similar but less exacting.

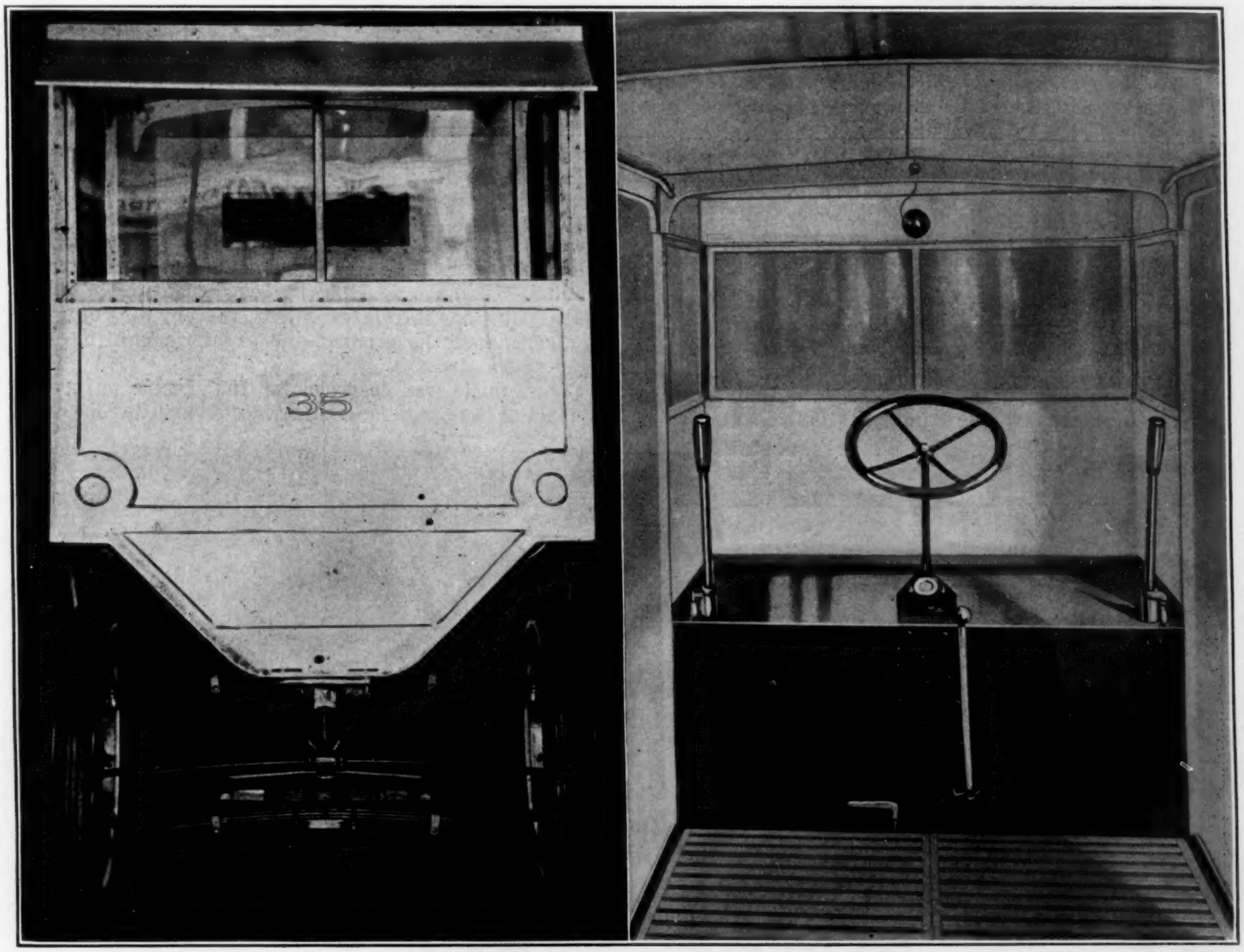


Fig. 4—Exterior and Interior of the Front

Instead of a Front Axle, a Pair of Transverse Suspension Springs Connect the Wheels and Support the Body. Right and Left-Hand Levers Each Operate the Clutch and Service Brake and also, by a Twisting Movement, Control the Throttle. A Two-Speed-and-Reverse Transmission Is Operated by the Central Lever below the Steering-Wheel, and a Pedal near the Floor Sets Metal-to-Metal Rear-Wheel Brakes. Safety Glass Is Used in the Windows. The Interior Is Painted or Lacquered To Provide for Washing

Fig. 1 shows in the chart at the left the items that are included in the total operating cost of the horse-drawn-wagon unit with the exception of such items as painting and washing. The reason for the elimination of these two items is obvious when consideration is given to the wide variability of these costs in different applications and at different plants in the same industry. The figures shown in this chart are minimum averages obtained from horse-drawn-wagon operation in various sections of the Country and should make possible easy computation and ready comparison with any actual horse-and-wagon costs. The cost groups include the following items:

Storage.—Space for housing the horse, wagon, harness, hay, grain, bedding, washrack, stockroom, repair-shop, and so on, charged at 50 cents per sq. ft. per year
Labor.—Combined cost of hostlers, wagon men, harness attendants and repair men; in fact, all labor other than washing
Hay, Grain and Bedding.—These costs represent an average of costs obtained since 1924
Depreciation.—Computed on a basis of 10 years' wagon life, 5 years' harness life and 5 years' horse life, including all losses
Insurance.—Charged at actual rates obtaining in Chicago for fire, theft, collision, property damage and public liability
Wagon Maintenance.—All repairs for a 10-year period not covered by insurance; painting not included
Shoeing.—Actual cost of keeping the horse shod under average year-round conditions in Chicago
Interest.—Charged at 6 per cent on the depreciated valuation during the life of the whole unit
Cleaning Supplies.—Cost of forks, brooms, brushes, combs, harness oils and dressings, sponges and many similar items
Incidentals.—Combined cost of veterinary service, harness repairs, blankets, lanterns, and so on
License.—The Chicago vehicle tax

This chart is carried out to a 30-mile day although the average day's mileage in the milk industry, for such equipment, is approximately 10.

The chart at the right in Fig. 1 shows the total operating costs of the Pak-Age-Car similarly. These costs are based on more than 2 years' actual delivery experience with experimental vehicles.

Depreciation.—Computed on a basis of 6 years' life on a schedule of 30 miles per day
Maintenance.—Cost of labor and material required to keep the vehicle in good operating condition. Painting and washing are not included and insurable repairs are deducted, as in the case of the horse and wagon
Insurance.—Charged at actual rates obtaining in Chicago for fire, theft, collision, property damage and public liability
Gasoline.—Charged at 16 cents per gal.
Tires.—Includes renewals and repairs at fleet-operator's cost
Garage Space.—Charged at 50 cents per sq. ft. per year; includes space for storage, wash-racks, stockrooms, repair-shop, and so forth
Interest.—Charged at 6 per cent on the depreciated valuation during the life of the vehicle
Licenses.—At Illinois and Chicago rates
Cleaning Materials.—Includes soap, sponges, and the like
Oil and Grease.—Charged at average costs in Chicago

It will be seen that the Pak-Age-Car will pay for itself out of savings in 3 years on the 10-mile-per-day basis.

In addition to its economy, this vehicle is incomparably more sanitary than animal-drawn equipment, has an advertising value which always will be an asset and will be a considerable one for some time due to the novel appearance of the vehicle, has considerably greater speed than the horse and wagon, and has a radius of operation that may be three times that possible with the horse-and-wagon unit. This greater radius will make feasible the concentration of distribution stations into large depots, thereby affording better control of the product and greater operating economy at the depot.

The vehicle was designed for the specific purpose of replacing the single-horse-drawn delivery wagon, which

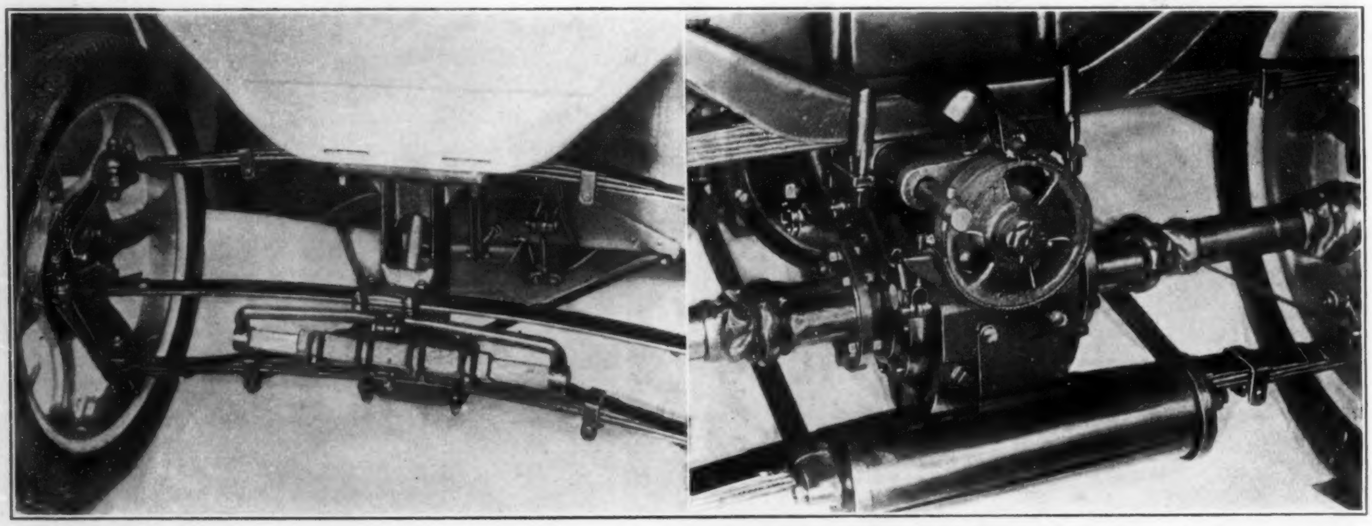


FIG. 5—FRONT AND REAR SUSPENSION AND LIVE-AXLE DRIVE

The Front Springs Terminate in Ball-and-Socket Connections That Take the Place of the King-Pin in the Usual Steering-Knuckle Assembly. The Steering Mechanism Has Merely a Resilient Tie-Rod with Connections Whereby Both Wheels Are Operated Directly. Variation in the Distance Between the Steering Arm and the Ball Joints Amounts to Only a Few Thousandths of an Inch as the Wheels Are Turned from One Extreme to the Other. The Only Axle Used at the Rear Is the Live Axle and the Only Unsprung Weight Is That of the Wheels. The Service Brake Is Mounted on the Drive-Worm Shaft, Where It Is Very Effective Because of the Large Reduction between the Worm and the Driving Gear. A Transverse Muffler Is Mounted at the Rear

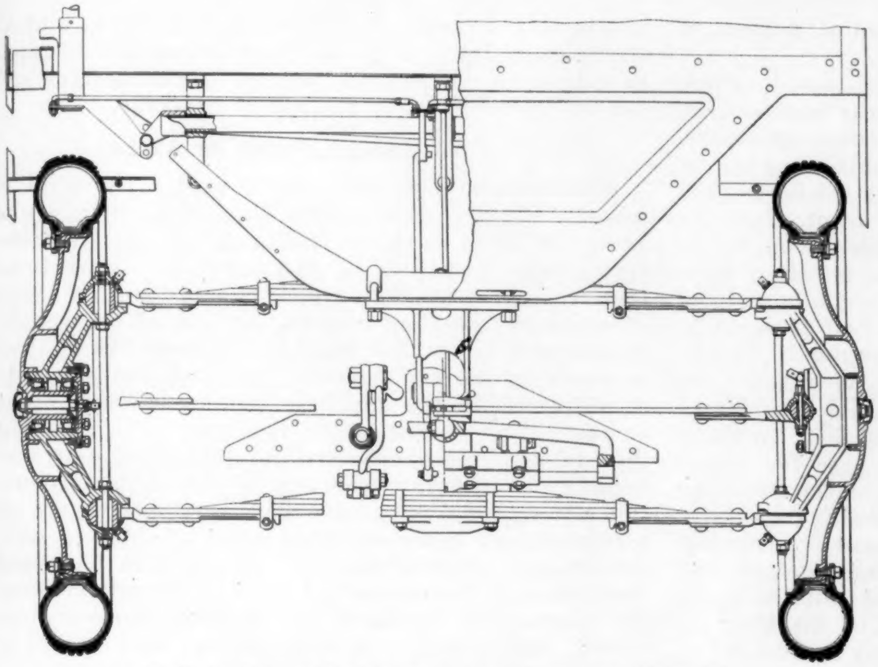


FIG. 6—FRONT SUSPENSION AND STEERING ASSEMBLY

heretofore has been more economical than an automotive vehicle for house-to-house delivery because of the high initial cost of the latter and the loss of time due to the necessity of the driver entering the vehicle and sitting down to operate the controls each time the car is moved to the next point of delivery. Under such circumstances, the superior speed and the tirelessness of the conventional mechanical vehicle do not compensate for the delays in delivery arising from the additional work imposed on the operator. Therefore, the Pak-Age-Car, shown in Fig. 2, was designed to provide a system of control adapted to render the operation of the vehicle as easy as possible and that would be on a parity with that of horse-drawn equipment by enabling the operator to advance the vehicle with no more delay than when a driver grasps the reins to drive or lead a horse to the next point of delivery.

This design has been in development for about 14 years, and intensive development work has been carried on during the last 4 years. In the preparation of the design it was thought desirable to build a vehicle in which the relation of net weight to weight of the useful load to be carried would be substantially better than it ordinarily is in motor-trucks of conventional design. This ratio is usually about 1 to 1 in heavy-duty trucks, whereas in the smaller trucks the weight of the vehicle generally is greater than the load it can carry, in some instances the weight of the truck with body being twice that of its carrying capacity. Pak-Age-Car weighs approximately 1800 lb. and will carry a net load of 3000 lb. which, with the driver, gives a gross weight of approximately 5000 lb. The ratio of useful carrying capacity to net weight of vehicle and driver is therefore $1\frac{1}{2}$ to 1, which is 50 per cent more than that of any other road motor-vehicle now being produced.

In building a vehicle of the type we regarded as essential for the service required, it was thought necessary to depart from conventional design in many respects, and this has been done. However, few details of the construction, taken by themselves, constitute new or untried principles. The design is largely a new combination of thoroughly established engineering principles.

It will be noted, in reading the specifications of this vehicle, that some details are not common to the conventional type of motor-vehicle. The engineers who designed it did not confine themselves to precedent in the automotive industry, and the result is that the vehicle includes some details from aviation practice, some from tractor practice and some from stationary-engine practice.

The body is made entirely of steel and metal-veneer panels. The panels are built up of several plies of wood to which thin sheets of metal are attached on either side. This construction affords an exceedingly strong panel of fair insulating quality and having a weight substantially less for its strength than is possible with any other available materials. The body, shown in assembly drawings in Fig. 3, is designed to be supported on the spring suspension at both front and rear. The side panels are 6 ft. deep, which, with the necessary stiffening members at the bottom, gives a total side-member depth of 74 in. This side member constitutes the equivalent of the side channel of the conventional automobile frame, and, when it is remembered that an 8-in. frame is a deep frame, some idea will be had of the strength of the Pak-Age-Car structure. Photographs of the body, reproduced in Fig. 4,

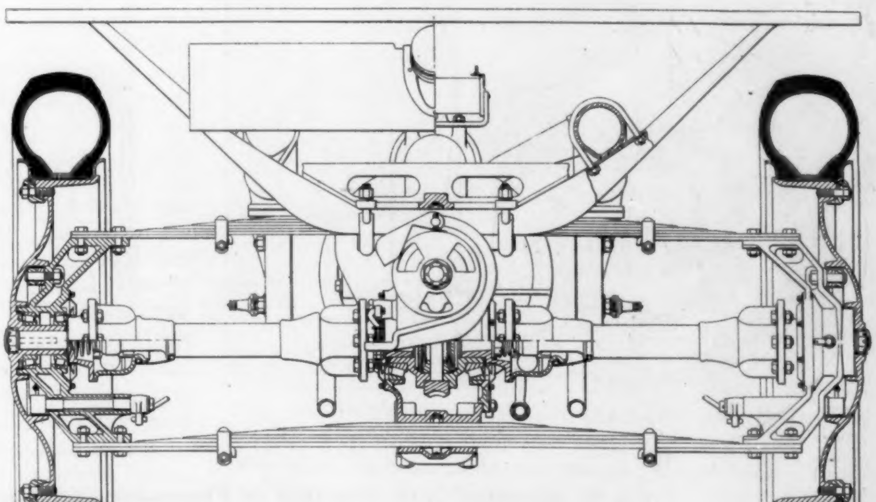


FIG. 7—REAR SUSPENSION AND DRIVE ASSEMBLY

show that it is a series of parallelograms, a form of construction that is unusually rigid.

Standard bodies are provided with brackets to which may be attached a great variety of racks such as may be required for holding milk cases or other containers. When so fitted, 27 of the largest-size milk cases can be carried on these racks, and, by utilizing the floor space available as well as the space in the front, about 40 such cases can be loaded into the body. The bodies are fitted with electric headlights, a tail-lamp with license bracket, an interior dome-light and a horn. The horn button is mounted on one of the roof truses in a location where it can be reached conveniently by the operator from any position while operating the vehicle.

Inside and out, the body is finished with a white undercoat material that is a suitable base for either oil paint or lacquer finishes. All the under-structure of the vehicle is painted with an asphaltic-base rust-resisting paint. The electrical equipment is protected so that the vehicle may be washed, both inside and out, with a hose with very little labor, and suitable drain holes are provided in the floor-plates of the body so that it will drain dry after the washing operation.

The volume of the standard body is approximately 216 cu. ft., of which substantially 160 cu. ft. are available for useful load; the remaining 56 cu. ft. are required by the driver for the operation of the vehicle and the handling of his load. Exceptionally good visibility is afforded ahead and on both sides, and a rear window, which is larger than in most motor-truck cabs, affords good visibility to the rear. Standing height in the center of the body is 6 ft. 3 in., and at the lowest point is 6 ft. All the windows are mounted in rubber in white-metal sash of special design, and can be replaced readily in case of breakage.

Has No Chassis Frame or Axles

Neither front nor rear axle is used. The body is mounted directly on transverse supporting springs, one above the other, as shown in Fig. 5. At the front the spring-ends terminate in ball-and-socket connections that replace the usual king-pin construction. This construction reduces the unsprung weight of the vehicle considerably below that possible with even the lightest conventional design. Wheels, tires and hub assembly constitute all of the unsprung weight at either front or rear. The weight of the live rear axle, including the final-drive mechanism and the differential, is transferred from unsprung to sprung weight. This construction not only makes possible a better-riding vehicle at a substantially lower cost than could be obtained with conventional construction, but also reduces the road shock through the wheels and bearings, thereby making for substantially increased life of all the parts so supported. When cushion or solid tires are used instead of pneumatic tires, the gains are of even more importance. The front and rear suspension incorporated in the vehicle, as shown in Figs. 6 and 7, reduces the number of points requiring lubrication. At least 10 spring-bolts required in the conventional construction are eliminated in Pak-Age-Car construction, and the only parts requiring frequent lubrication, other than the powerplant proper, are the steering connections. These

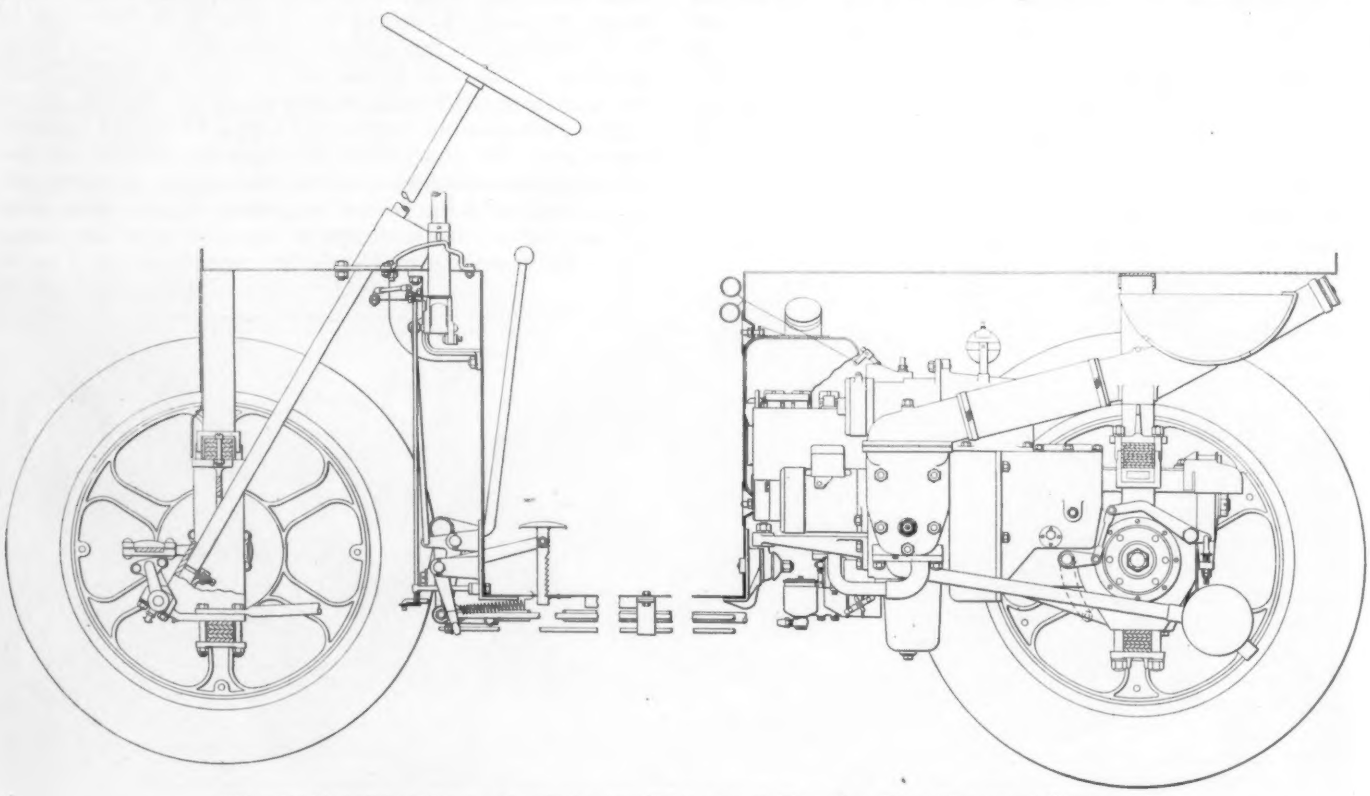


Fig. 8—Running-Gear Assembly of Frameless Pak-Age-Car Delivery Vehicle

Front and Rear Units Are Self-Contained and Are Secured Directly to the Body, the Large Stiff Side-Panels of Which Give Support to the Load and Make the Conventional Chassis Side-Frames Unnecessary. Axles Are Dispensed with, the Body Being Suspended on Two Pairs of Transverse Springs That Take the Place of Axles. Placing the Engine under the Rear in a Removable Powerplant and Transmission Unit, and Mounting the Steering Column and Its Connections Forward of the Front Springs, Result in an Extremely Short Wheelbase. One of the Dual Control Levers Is Shown Directly Below the Steering-Wheel. Back of and Beneath This Is the Change-Speed Lever, and Below the Latter Is the Brake Pedal

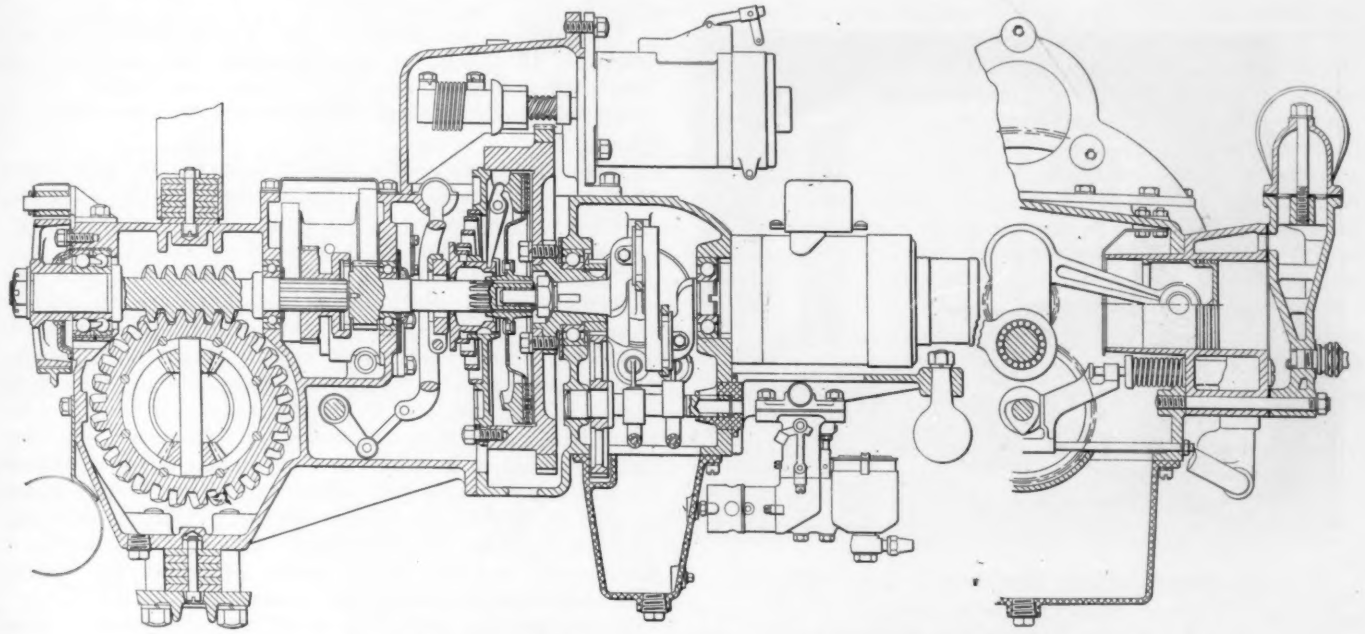


FIG. 9—POWERPLANT, TRANSMISSION AND DRIVE UNIT

The Two-Cylinder Horizontal Opposed Engine Operating at Relatively Low Speed Is Rated at 4½ Hp. but Develops about 10 B-Hp. This Drives through a Large Single-Plate Dry Clutch to a Selective Two-Speed Transmission. Final Drive Is by Worm and Worm Gear to a Double Universal-Jointed Live Axle. A Transverse Cross-Section through One Cylinder of the Engine Is Shown at the Right

should be lubricated frequently, and Alemite fittings are provided for this purpose. All the control linkage is mounted in self-lubricated bearings of bronze composition impregnated with graphite.

Heretofore, steering mechanisms have involved a reducing mechanism connected to a steering-arm, a connecting-rod leading to the steering-knuckle of one wheel, and a tie-rod connecting the knuckles of the two wheels. In such a system the second wheel must derive its motion from the first wheel and consequently every element entering into the connection is a possible source of error and trouble in addition to the added bearings requiring lubrication. The steering mechanism of the Pak-Age-Car has merely a resilient tie-rod with connections whereby both wheels are operated directly; the usual gear arm, connecting-rod and extra knuckle-arm are eliminated.

Steering a vehicle mounted on double transverse springs always has been a problem, as with this suspension the distance between the king-pin centers is subject to continual variation. If a rigid parallel bar is employed, the front wheels will shimmy even on very smooth pavement. In nearly all of the vehicles built abroad employing double transverse suspension on the front a flexible connection has been used between the steering-arms; and, in the very cheap jobs, this has taken the form of a wire cable wrapped around a spool, with each end of the cable connected to its respective steering-arm. On some of the more expensive vehicles abroad and in practically all of those built in this Country, the parallel connection has been in the form of a jointed bar. However, neither the flexible cord nor the jointed bar eliminates the tendency to shimmy; the cable connection is obviously a device which could not be sold in this Country, and the jointed bar, with its many connections, is rather expensive and very unsatisfactory in service.

The construction that we employ reduces the difference between the steering-arm and the king-pin centers to a very few thousandths of an inch. While this is a variable error as the wheels are turned from one extreme to the other, it is never sufficient, on even rough pavement, to permit any visible evidence of shimmying. All the connections are ball-and-socket joints, and they are loaded in such a way that even a considerable amount of wear will not increase the error. Neither does this construction involve the use of a single additional bearing or bushing requiring lubrication.

Control of the vehicle is through a conventional Borg & Beck clutch of very large size, a two-speed-and-

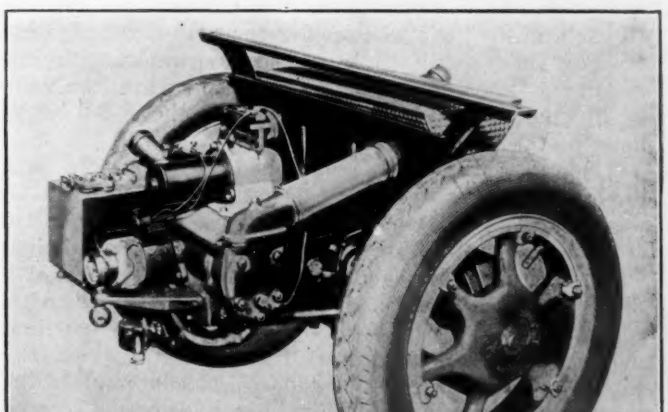


FIG. 10—INTERCHANGEABLE POWERPLANT AND REAR-END ASSEMBLY

This Unit, Comprised of the Engine. Transmission, Driving Mechanism and Rear Wheels, Is Easily and Quickly Removable from the Vehicle Without Entering the Body or Disturbing the Load. Service Is Greatly Facilitated and Reduced in Cost by This Construction. A Few Replacement Units Suffice for a Large Fleet, and Adjustments Can Be Made and Repair Work Done in the Shop with Proper Facilities. Reserve Units Can Be Placed in a Stalled Vehicle on the Road or in the Shop with the Minimum of Lost Vehicle-Time

FIG. 11—REMOVING THE POWERPLANT AND DRIVE UNIT

It Is Not Necessary for the Mechanics To Enter the Vehicle or Disturb the Load When Replacing the Power-and-Drive Unit, an Operation That Can Be Performed in 20 Min. Very Few Spare Units Are Needed To Keep a Fleet of Vehicles in Continuous Service, and All Adjustments and Repairs on the Units Can Be Made in the Shop Under Good Working Conditions

reverse transmission, a dual system of brakes, and the usual carbureter throttle. The linkage effecting this control is unusual in that the clutch and the service brake are controlled with the same lever by a fore-and-aft movement, while the throttle is controlled by a twisting motion of the lever. This control lever is in duplicate, one on either side of the steering-wheel and located conveniently immediately forward of the front door-post, as shown in Fig. 4. The service brake, which is interconnected with the clutch, is on the worm shaft, where it is exceedingly effective because of the reduction of the worm gear. Brakes are also provided in each of the rear wheels, for the primary purpose of holding the vehicle on hills and to comply with laws requiring wheel brakes. These brakes are controlled by a pedal equipped with a locking ratchet. All brakes have metal-to-metal contact.

The transmission is controlled by a single lever having a dual motion and located conveniently in the vertical panel of the body that rises between the two front door-posts. Under normal operating conditions, with high gear engaged, this lever stands parallel to the front panel, where it is out of the way, with the operating grip just above the break in the panel, as shown in the side elevation of the running gear, Fig. 8. The scheme of operation does not contemplate frequent gear changing, as the vehicle is designed to start readily on high gear under normal conditions. A suitable lock is provided for the control levers that operate the clutch and service brake so that, when the brake is applied, the clutch is locked out and the operator may leave the vehicle with the gear engaged. This condition is almost identical with that obtained in the Ford car when the operator pulls back the brake lever. Transmission-gear changes may be effected, if desired, when the service brake is applied. Low gear is engaged when the lever is in the backward position and the transmission is in neutral when the lever is in halfway position.

The vehicle is designed for a maximum full-load speed of 15 m.p.h., or approximately two and one-half times the maximum speed of a horse and wagon. Without load the maximum speed of the power wagon is 18 m.p.h.

When equipped with standard body the wheelbase of the vehicle is 92½ in., the over-all length 123½ in., and the over-all height 7 ft. 4 in. With standard body, the vehicle will turn in a 30-ft.-wide street.

Particular attention is called to the fact that the extreme over-all width is 53 in.; there are no projections of any nature beyond this dimension. As a result, the vehicle maneuvers well in traffic, and the operator has only to watch the clearance of the front corner of the body; it is not necessary for him to consider projecting hubs, fenders, or bumpers. The car parks readily in a much smaller space than is required by any other four-wheel vehicle, and the storage space needed is only 50 sq. ft. per vehicle, which, in this day of high rentals, is important. Allowing 60 sq. ft. of floor space per car gives ample provision for necessary movements around the vehicle.

Under normal operating conditions the gasoline consumption does not exceed 1 qt. per hr., and 1 qt. of engine oil per week suffices for lubrication.

SPECIALLY DESIGNED TWO-CYLINDER OPPOSED ENGINE

The engine, which was designed by Pak-Age-Car engineers, is rated at 4½ hp. and produces about 10 b-hp. It has two horizontal opposed cylinders of 3⅛-in. bore and 3-in. stroke. A hardened and ground alloy-steel crankshaft is used, on which are mounted roller-bearing connecting-rods and ball bearings for the main bearings. The pistons are of grey iron. This type of engine was selected and designed because we felt that it offered more possibilities for the particular class of service than any other type. In the first place, we desired the shortest possible engine; secondly, we required an engine that would give continuous service without attention. Very small bore high-speed high-compression engines are tremendously interesting but, as leakage is a function of pressure, such engines would not be practical for our class of service. A very small gas leak causes these engines to run irregularly, and this occasions considerable vibration and relatively great power losses. On the other hand, the Pak-Age-Car engine will continue to run and give fairly satisfactory service even when it is in very bad mechanical condition.

The use of ball main bearings on the crankshaft and Hoffman rollers on the connecting-rods gives an exceedingly short couple between the throws of the crankshaft, and this results in a very smooth-running engine.

Valve motion is effected by the use of a U-shaped follower on the cam whereby a mechanical return is obtained that enables us to use very light valve springs. This construction also makes it possible to set the valve stems parallel to the cylinder-bore without involving side thrust on the stems. Valve clearance is established by gaging the length of the stems before the cylinders are assembled to the crankcase. This engine is mechanically quiet and smooth, and an extra-large-size muffler is provided to adequately silence the exhaust.

The engine is lubricated by a modified splash oil-

ing-system which has an oil-level cock in the crank-case and a filler neck that can be reached conveniently from the right-hand side of the vehicle.

Powerplant Assembly Readily Removable

The powerplant, of which Fig. 9 is an assembly drawing, consists of the engine with all of its accessories, the clutch, transmission, and the final worm-drive assembly, which includes the service brake. Due to the peculiarity of construction, all of these parts are assembled as one unit, together with the rear springs, hubs, wheels and tires, as in Fig. 10. This unit can be replaced in 20 min. from the time the service man arrives on the spot with a spare powerplant, and replacement can be made without the service mechanic entering the body of the vehicle or disturbing its load, as shown in Fig. 11. This operation can be done so quickly and easily that it is preferable as a rule to make a powerplant exchange rather than attempt to make any adjustments to the vehicle on the road. By handling the service in this way, the operator can assure himself that proper adjustments will be made by competent mechanics provided with proper facilities for such work. This is important. particularly in the case of operators of large fleets, as very few spare units are needed to assure that all of the vehicles of a fleet will be maintained in continuous service.

Tire equipment consists of 29 x 4.40-in. balloon tires on the front wheels and 30 x 5-in. heavy-duty tires on the rear wheels. These are interchangeable with the tires on the Ford 1-ton truck.

The Labor Market and Foreign Trade

BEFORE 1914, as is well known, chemical industries, and especially those yielding highly elaborated coal-tar products, were more successfully carried on in Germany than in any other country. Coal-tar dyes and drugs were supplied to England and the United States from Germany; the domestic output in these countries was negligible. Other countries also were supplied by German imports, though not as preponderantly as the two English-speaking countries. The Germans evidently had some advantage in making these things. A comparative advantage? Certainly not one of a natural, physical, sort. It arose largely from the plenty and the especial cheapness of a particular kind of labor; that of chemists and of chemists' skilled assistants. Germany had a learned proletariat. The excellence and easy access of technological education, and the powerful social forces which attracted large numbers from the middle classes into the learned professions, brought about a large supply and a low remuneration of highly trained chemists. A similar excellence of intermediate education supplied to these officers a capable non-commissioned staff, to use a military analogy; there was a supply of exact, careful assistants and workmen, also paid at rates low in comparison to those of other countries.

I will not say that this was the only factor that served to give Germany her unique position in the coal-tar industries. There were others, not least the marked faculty for elaborated organization which had developed during the latter years of the Nineteenth Century; a faculty that told with special effect in an industry like this, intricate, large in its scale of operation, yet not characterized by mass production. For the present purpose it is enough to note the influence of the labor situation. The special cheapness of the types of labor needed to an unusual degree in the industry served to give it a comparative advantage, that is, an advantage in the pecuniary terms which are decisive in the markets. And the advantage doubtless was not confined to the coal-tar and other chemical industries. It was probably generic. It appeared in scientific industries of other kinds, such as for example the making of optical instruments, surgical instruments, laboratory apparatus. Not one industry only, but a considerable number of German industries similar in character were given a place of their own in international trade because of the special position in Germany of the grade of labor needed for their products.

American Industries Built on Unskilled Labor

Quite a different illustration, derived from the situation of a group lying not in the upper line of workers but in the lower, is to be found in the United States during the same period. A marked peculiarity of the American labor situation during the generation preceding the Great War was the comparatively low rate of pay for the unskilled laborers. It was low, that is, in comparison with the pay of the upper stratum of the skilled laborers. While the pick and shovel man got more in the United States than in Europe, he did not get as much more above the European rate as did the American mechanic. The differential in favor of the mechanic was greater in the United States; the unskilled were relatively cheap, even though not absolutely so, for the American employer. The cause is not far to seek. The enormous influx of immigrants maintained a great supply of unskilled labor and kept down its rate of pay.

In the manufacturing industries of the Southern States the utilization of the low-lying stratum of "poor whites," not to mention the negroes, operated in the same way. The effect was to give an advantage to those industries, or those ways of conducting industries, in which the low-lying group of labor was used in large proportion. Industries of this type were accordingly in the same position in regard to international trade as if they had a comparative advantage; or, if not so much as this, something to offset a lack of such advantage.

In the iron industry, that is, in the making of crude and half-finished iron and steel, the effect was of the former sort; the situation served to give a comparative advantage. The industry uses great masses of labor. The industry grew in the United States at an extraordinary pace between 1890 and 1915, and came to be an important industry of export. Here, too, the labor factor was not the only one; but it was an important one. It contributed to the remarkable overturn by which the United States, formerly an importer of iron and steel, became a great exporter of them.

These peculiarities in the American labor situation did not rest on permanent causes. They were due, as has already been said, primarily to the great inflow of immigrants during the period in question. The restrictive legislation of 1916 brought a complete change, one whose effects will ramify far and in many directions, but in no way more than in a new adjustment of the relative wages of skilled and unskilled laborers. The differential will become less pronounced in favor of the skilled as against the unskilled. The industries which have adjusted themselves to a large and relatively cheap supply of the unskilled will have to readjust their ways. So far as they are subject to competition from foreign industries, they will be in a less advantageous position than before. The relations between the wages of the two groups will probably come to be in the United States not different from those in England, in Germany, and in Australia. This particular source of comparative advantage, or of an offset to a comparative disadvantage, will grow less and less, and probably will in the end disappear.—F. W. Taussig, in *International Trade.*

Engine and Car Performance

By W. S. James[1]

Metropolitan Section Paper *Illustrated with* Charts

An attempt is made to show in their relative importance the more important of the major factors affecting car performance. The items dependent upon engine design that are considered are acceleration, hill-climbing ability, fuel consumption and maximum speed. The factors entering into engine and car design that are discussed are the size and speed of the engine, the compression ratio and the weight of the car. Experimental data have been used only in establishing reasonable engine and car characteristics. The effects of the changes desired were estimated on what are believed to be generally accepted bases.

The most important conclusion drawn is that the standard of car performance now taken for granted by the public can be obtained in more than one way, and that a little of each method, tempered with other considerations such as cost of manufacture, cost of maintenance, smoothness of operation, and good low-speed operation, will give the result demanded by the hard laws of engineering economics. The author contends that giving the public the kind of transportation it wants at low cost is more important than arguments over the comparative merits of engineering features that it deems of minor significance.

The major factors affecting car performance are well known. Each has been discussed separately in detail many times. Another discussion of any one of these factors is, therefore, of little interest except as it is affected by new developments. Few attempts have been made, however, to present the more important of these factors in a way that will show their relative importance. This paper is such an attempt.

The items of car performance considered herein that are dependent upon engine design are acceleration, hill-climbing ability, fuel consumption and maximum speed. Other items, such as smoothness, quietness, life, and the like, although of equal importance, are not discussed. The factors in engine and car design that are considered are the size and speed of the engine, the compression ratio, and the weight of the car.

In making comparison of the effect of these changes in engine design on car performance, experimental data have been used only in establishing reasonable engine and car characteristics. The effects of the changes desired have then been estimated on what are believed to be generally accepted bases.

I should like to make clear the reason that this paper may seem to be based on hypothetical grounds. When any attempt is made to vary such factors as engine size, engine-speed and compression ratio, with very little change in the details of design, considerable difficulty is encountered. I have tried, therefore, to assume a very reasonable basis of engine design in general, and make the assumption that a consistent engine design is followed in all cases. This is not the case with commercial engines as they are built today; consequently, it is almost impossible to make complete experimental comparisons of two engines, say of different piston displacement, because of differences in design.

Assumptions Made and Their Algebraic Expressions

The following assumptions have been made:

(1) The indicated mean effective pressure of an engine is proportional to the weight of air entering the cylinders and to the air-cycle efficiency. This means that the indicated mean effective pressure goes down as the manifold pressure goes down. This assumption has been experimentally demonstrated many times

(2) The weight of air entering the engine is proportional to the ratio of the cylinder pressure, when the intake valve closes, to the atmospheric pressure. This assumes that the temperature of the air in the cylinder is the same as that of the air entering the carbureter. This, of course, is not true, but is largely offset by the next assumption

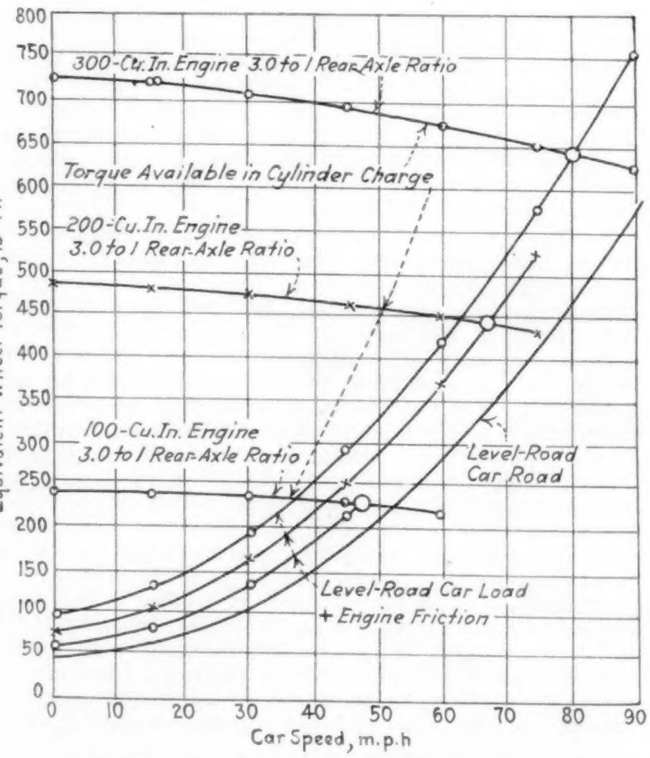


Fig. 1—Equivalent Wheel-Torque versus Car Speed for Engines of Different Piston Displacements and the Same Axle-Ratio

The Intersections of the Engine and Car Friction Curves with the Curves of Indicated Mean Effective Pressure Give the Maximum Speed of the Car, Which Can Be Seen at These Three Points

[1] M.S.A.E.—Research engineer, Studebaker Corporation of America, South Bend, Ind.

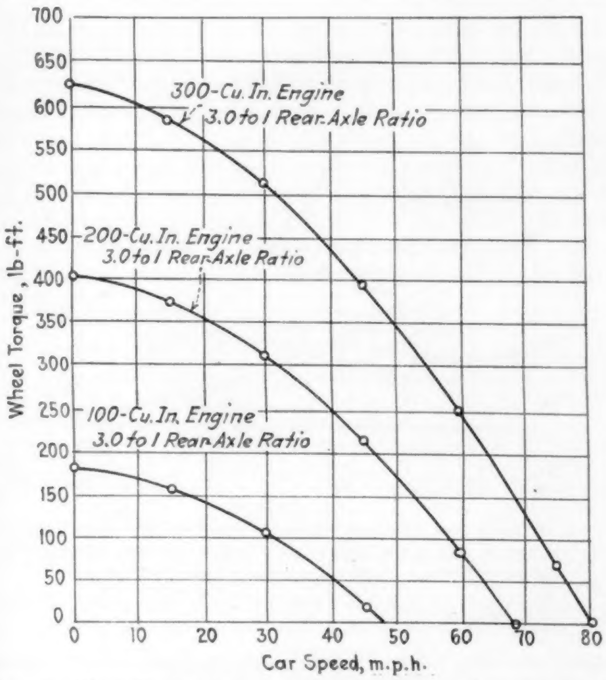


Fig. 2—Hill-Climbing and Accelerating Ability of Engines of Different Displacements and the Same Axle-Ratio

To Find the Ability of the Car, the Difference between the Engine Friction Plus the Car Load and the Indicated Mean Effective Pressure Was Obtained and Plotted. The Height of the Line Indicates the Ability of the Car Either to Accelerate or to Climb Hills

(3) The weight of air entering the cylinder is reduced by the expansion of the residual gases, from the pressure at the closing of the exhaust valve to the pressure in the intake manifold. The effect of the cooling of the exhaust gases is neglected

These three assumptions were checked with experimental data from several engines and good agreement was obtained. A constant representative of good designs was then selected. The algebraic expression for these assumptions is

$$\text{I.M.E.P.}_N = \frac{P_m}{P_a} \frac{\left[\frac{D}{Cl} - \left(\frac{P_a}{P_m}\right)^{\frac{1}{S}}\right]}{\left[\frac{D}{Cl} - 1\right]} \text{I.M.E.P.}_{max.} \qquad (1)$$

where

I.M.E.P.$_N$ = Indicated mean effective pressure at N r.p.m.

I.M.E.P.$_{max.}$ = Maximum indicated mean effective pressure, assumed to be at 0 r.p.m.

$\frac{P_m}{P_a}$ = Ratio of the manifold pressure to the atmospheric pressure

D = Swept volume of the cylinder

Cl = Clearance volume of the cylinder

S = Ratio of the specific heats, assumed as 1.3

The ratio $\frac{P_m}{P_a}$ was found experimentally to vary with the speed in the following relation:

$$\frac{P_m}{P_a} = \frac{1}{1 + KN^2} \qquad (2)$$

where K was found to be 14×10^{-9}

(4) The friction mean effective pressure can be divided into three parts: (a) a part that is independent of the engine speed; (b) a part that increases in proportion to the engine-speed; and (c) the work necessary to pump the air entering the engine from the intake-manifold pressure to the exhaust pressure; that is, the atmospheric pressure

After an examination of the experimental data on the friction losses in several engines, experimental constants were determined. The algebraic expression for these three assumptions is:

$$\text{F.M.E.P.} = A + BN + C\frac{\frac{P_m}{P_a}\left[\frac{D}{Cl} - \left(\frac{P_a}{P_m}\right)^{\frac{1}{S}}\right]}{\left[\frac{D}{Cl} - 1\right]}\left[\left(\frac{P_m}{P_a}\right)^{\frac{S-1}{S}} - 1\right] \qquad (3)$$

The values of the experimental constants are

$A = 8.5000$
$B = 0.0063$
$C = 138.0000$

It will be noticed that the first term of this expression includes all the metal-to-metal friction losses, and that the second term includes the oil-film shear losses. The term for the pumping losses is an attempt to express this much-discussed item on a reasonable assumption. The constants given were selected after an examination of a number of engines with respect to their friction mean effective pressure.

(5) The fuel consumption in pounds per indicated horsepower-hour was assumed to be constant for all engine-speeds and to vary with the compression ratio in accordance with the air-cycle efficiency. The fuel consumption in pounds per indicated horsepower-hour has been found experimentally to remain constant over a wide range of speeds, but to rise at very low speeds. The change in fuel consumption with change in the compression ratio has been found experimentally to follow the air-cycle efficiency relation very closely

(6) The resistance that must be overcome in order to drive the car was assumed to be made up of two factors: (a) the rolling resistance, which is independent of the speed, and (b) the

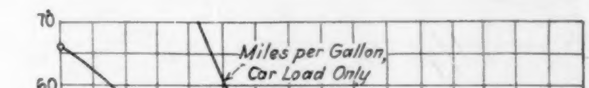


Fig. 3—Miles per Gallon versus Car Speed for Engines of Different Displacements and the Same Axle-Ratio

The Upper Curves Are for Part-Throttle Loads. The Miles per Gallon at Full Throttle Are Shown by the Relatively Straight Lines at the Bottom

wind resistance, which increases as the frontal area and as the square of the speed

Algebraically this can be expressed by

$$T = \alpha W + bAV^2 \qquad (4)$$

This form of expression has been found to agree excellently with the results obtained by experiment. The constants selected for a 3500-lb. car having 24 sq. ft. of frontal area were

$a = 35$, or 10 lb. per 1000 lb. of car weight
$b = 0.0022$, when v is in miles per hour and A is in square feet

With a rolling radius of 15 in., the wheel torque necessary to drive the car would be

$$t = 43.7 + 0.065\ v^2 \qquad (5)$$

An expression of this kind will come very close to giving the power required to drive a car. I should like to bring out the importance of wind resistance. The

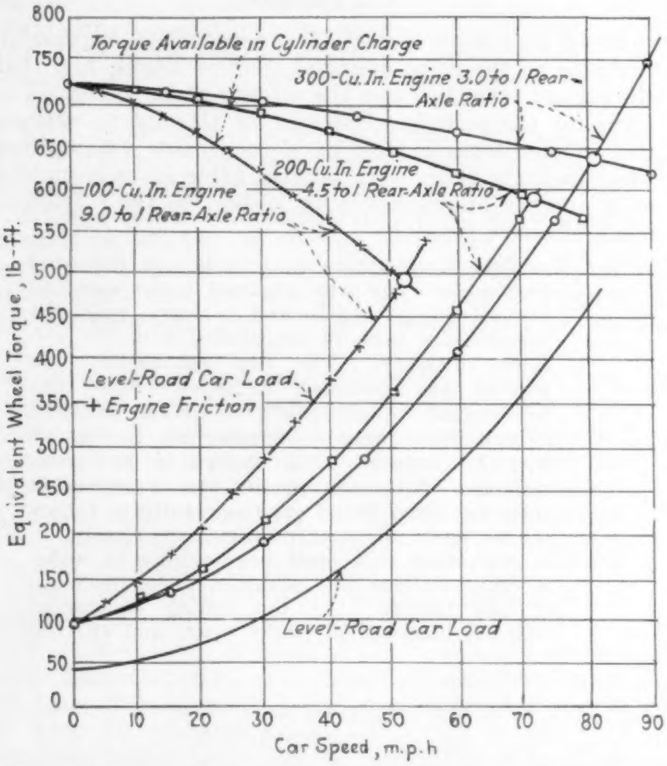


FIG. 4—WHEEL TORQUE VERSUS CAR SPEED FOR ENGINES OF DIFFERENT DISPLACEMENTS AND AXLE RATIOS GIVING THE SAME PISTON-DISPLACEMENT PER TON-MILE

Because of the Higher Engine-Speed at a Given Car-Speed, the Engine Friction Is Increased, and, in the Case of Cars Having 4.5-to-1 and 9.0-to-1 Rear-Axle Ratios, the Top Speed Is Reduced

coefficient 0.0022 when viewed from an aerodynamic point of view is very poor. If the ladies would let the engineers design the style of our automobile bodies from aerodynamical considerations instead of from Parisian views, this coefficient could probably be made 0.0006, which would require something less than one-third the present engine power. From 25 to 30 m.p.h. of wind resistance is equal to the rolling resistance of the car.

METHOD OF MAKING COMPARISONS

With these assumptions, which are reasonable and can be well supported with experimental evidence, it is possible to compare the effects of changes in piston displacement, engine-speed, compression ratio and car

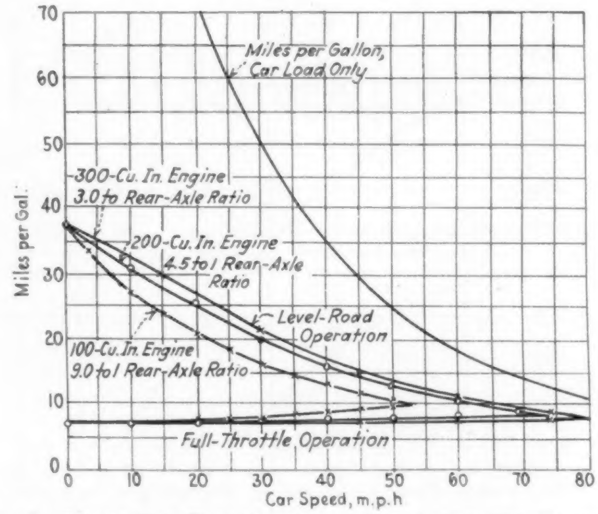


FIG. 5—MILES PER GALLON VERSUS CAR SPEED FOR ENGINES OF DIFFERENT DISPLACEMENT AND AXLE RATIOS GIVING THE SAME PISTON-DISPLACEMENT PER TON-MILE

The Acceleration Is the Difference Between the Indicated Mean Effective Pressure and the Engine and Car Load

weight on car performance; that is, on acceleration, hill climbing, maximum speed and gasoline mileage.

In making these comparisons the following method has been used:

For each case selected, the full-throttle indicated mean effective pressure for the range of speeds desired was expressed as wheel torque. The full-throttle friction mean effective pressure was then obtained, and, after being expressed in terms of wheel torque, was added to the wheel torque required to drive the car. The difference between these two values for any given car-speed gives a measure of the accelerating and hill-climbing ability of the car. The car speed at which the curve of full-throttle indicated mean effective pressure crosses

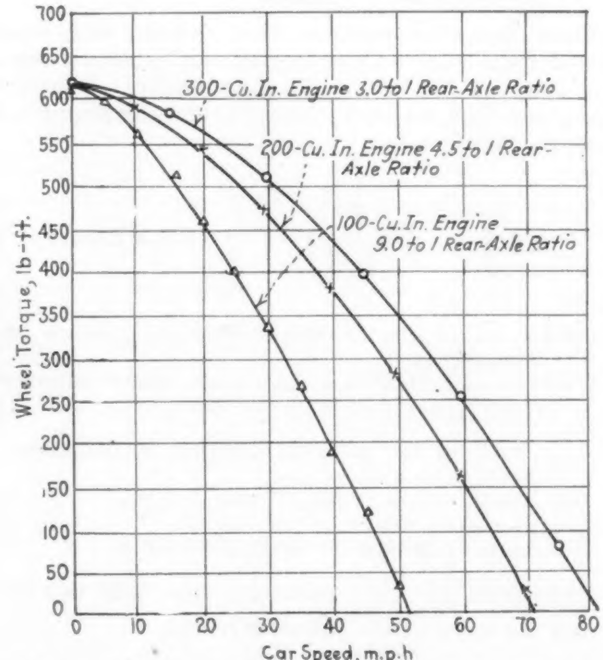


FIG. 6—HILL-CLIMBING AND ACCELERATING ABILITY OF ENGINES OF DIFFERENT DISPLACEMENTS AND AXLE RATIOS GIVING THE SAME PISTON-DISPLACEMENT PER TON-MILE

It Is Clear That Lower Axle-Ratio for the Same Piston-Displacement Gives Lower Accelerating-Ability. The Top Speeds Are Changed Very Little

the curve of car-plus-engine friction gives the maximum speed of the car. In obtaining the miles per gallon of the several combinations, the part-throttle indicated mean effective pressure that equaled the sum of the car and engine frictions was selected. As the pumping losses increased as the part-throttle mean effective pressure was decreased, it was necessary to find by trial and error the point at which the car and engine frictions just equaled the indicated mean effective pressure. As the miles per gallon is proportional to the miles per

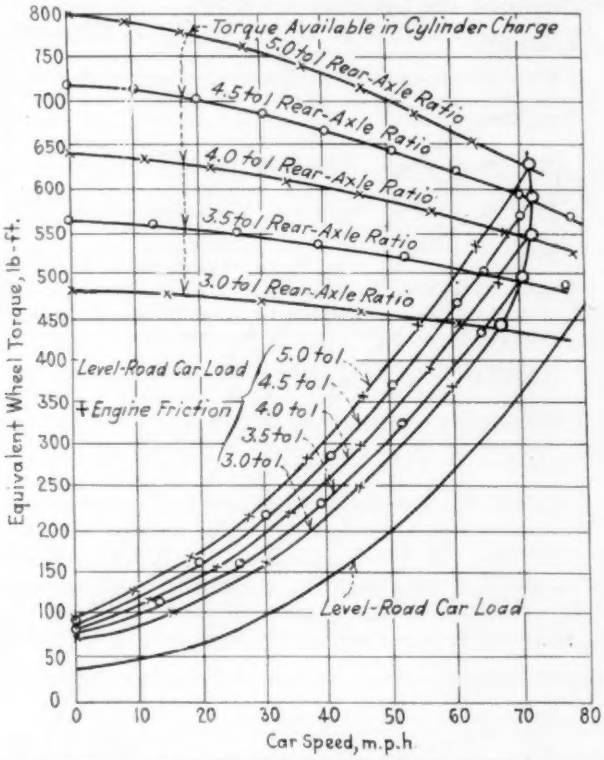


FIG. 7—WHEEL TORQUE VERSUS CAR SPEED FOR 200-CU. IN. ENGINE AND SEVERAL AXLE-RATIOS

The Miles per Gallon Are Greater for a Car Having 3.0-to-1 Rear-Angle Ratio than for One Having 5.0-to-1 Ratio

British thermal unit, the indicated foot-pounds required for driving and the indicated thermal efficiency are all that is required to obtain the miles per gallon of fuel.

RESULTS OF THE COMPUTATIONS

The results of these computations are given in Figs. 1 to 12. The cases selected are:

(1) Three engines of 100, 200, and 300-cu. in. piston-displacement in the same car, and using the same rear-axle ratio; namely, 3.0 to 1
(2) One engine of 200-cu. in. piston-displacement, but using rear-axle ratios of 3.0, 3.5, 4.0, 4.5 and 5.0 to 1 in the same car
(3) Three combinations of engine and axle ratios that give the same piston-displacement per ton-mile. These combinations are: (*a*) a 100-cu. in. engine having a 9.0-to-1 rear-axle ratio; (*b*) a 200-cu. in. engine having a 4.5-to-1 rear-axle ratio; and (*c*) a 300-cu. in. engine having a 3.0-to-1 rear-axle ratio
(4) Four engines of 200-cu. in. piston-displacement and 4.5-to-1 rear-axle ratio, but having compression ratios of 4.0, 5.0, 6.0 and 7.0 to 1

The curves shown in Fig. 1 are, first, a comparison of engines of various sizes, one being an engine of 300-cu. in., the second, 200-cu. in., and the third, 100-cu. in. piston-displacement. The rear-axle ratios are the same. The intersections of the engine and car-friction curves with the curves of indicated mean effective pressure give the maximum speed of the car, which can be seen at these three points.

To get the ability of the car, the difference between the engine friction plus the car load and the indicated mean effective pressure was obtained and plotted as shown in Fig. 2. The height of the line indicates the ability of the car either to accelerate or to climb hills. These cars are unnatural from about 10 or 15 m.p.h. to zero, because normally the indicated mean effective pressure of an engine drops at the lower speeds. The comparison, however, is good.

Fig. 3 shows a comparison in miles per gallon of three engines of different sizes but equal in other respects. At about 30 m.p.h. the curve gives 50 miles per gal. for the car alone with no engine friction. The other curves, the upper one being for an engine having 100, the next for 200, and the last for 300-cu. in. piston-displacement, are for part-throttle loads. The miles per gallon at full throttle are shown by the relatively straight lines at the bottom of the plot.

The comparison shown in Fig. 4 is of a 200-cu. in. engine with rear-axle ratios varying from 3.0 to 1 to 9.0 to 1. Because of the higher engine-speed at a given car-speed, the engine friction is increased and, in the case of the cars having 4.5-to-1 and 9.0-to-1 rear-axle ratios, the top speed is reduced.

The acceleration shown in Fig. 5 is the difference between the indicated mean effective pressure and the engine and car load.

In Fig. 6, it is clear that lower axle-ratio for the same piston-displacement gives lower accelerating-ability. The top speeds are changed very little.

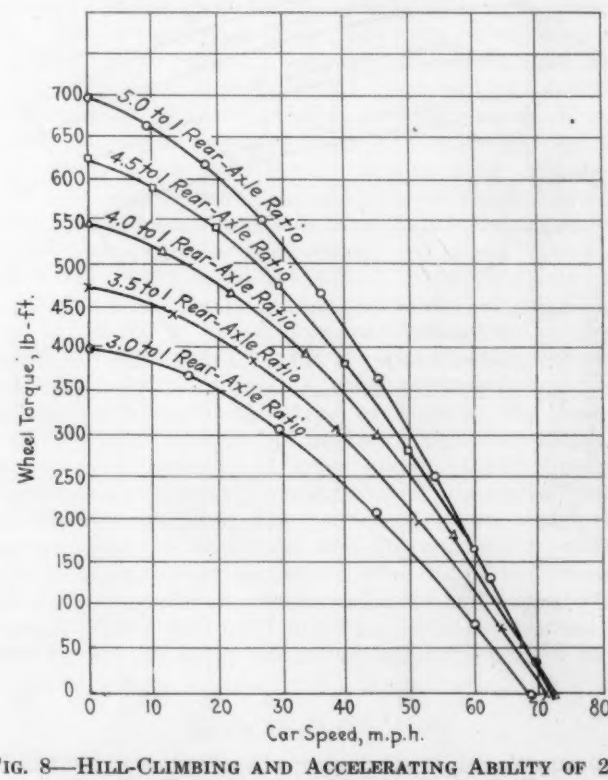


FIG. 8—HILL-CLIMBING AND ACCELERATING ABILITY OF 200-CU. IN. ENGINE WITH SEVERAL AXLE-RATIOS

This Curve Shows the Relative Ability of the Three Engines. The Reason for the Difference Is Primarily in the Engine-Speed and the Engine Friction

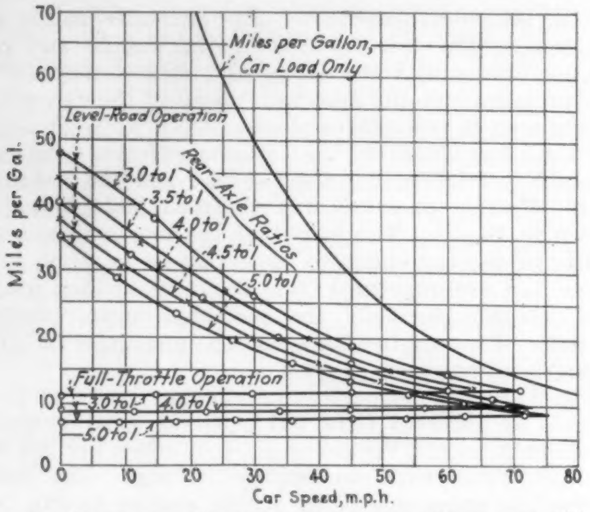


FIG. 9—MILES PER GALLON VERSUS CAR SPEED FOR 200-CU. IN. ENGINE WITH SEVERAL AXLE-RATIOS

The Same Relation Is Seen Here as in Fig. 8. The Largest Engine Running More Slowly Gives More Miles per Gallon than Either of the Other Two Engines

As shown in Fig. 7, the reverse is true of the economy, the miles per gallon being greater for a car having a 3.0-to-1 rear-axle ratio than for one having a 5.0-to-1 ratio.

CURVES FOR EQUAL DISPLACEMENT-TO-WORK RELATION

In the next three curves, shown in Figs. 8, 9 and 10, comparisons are made between three combinations of

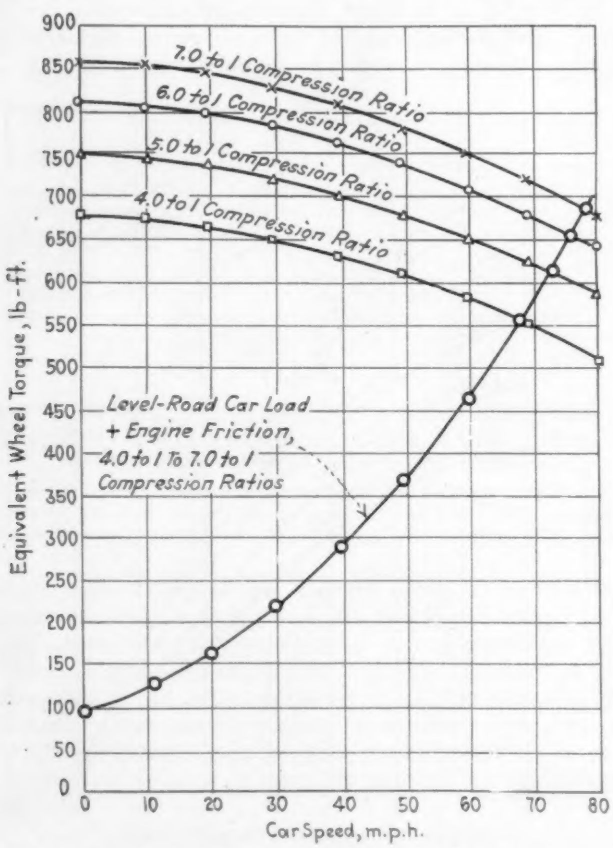


FIG. 10—WHEEL TORQUE VERSUS CAR SPEED FOR 200-CU. IN. ENGINE WITH VARIOUS COMPRESSION-RATIOS

The Four Ratios Selected Are 4.0 to 1, 5.0 to 1, 6.0 to 1 and 7.0 to 1, the Last Being Somewhat Higher than That Used in Cars Today

engine size and axle ratio, so that the piston displacement per ton-mile remains the same. The curve for lower indicated mean effective pressure corresponds to a 100-cu. in. engine and a 9.0-to-1 rear-axle ratio; the next, to a 200-cu. in. engine with 4.5-to-1 rear-axle ratio; and the last a 300-cu. in. engine with 3.0-to-1 rear-axle ratio. The top speeds are indicated by circles at the intersections.

The curve in Fig. 8 shows the relative ability of the three engines. The difference is due primarily to the engine-speed and the engine friction.

In miles per gallon, as shown in Fig. 9, the same re-

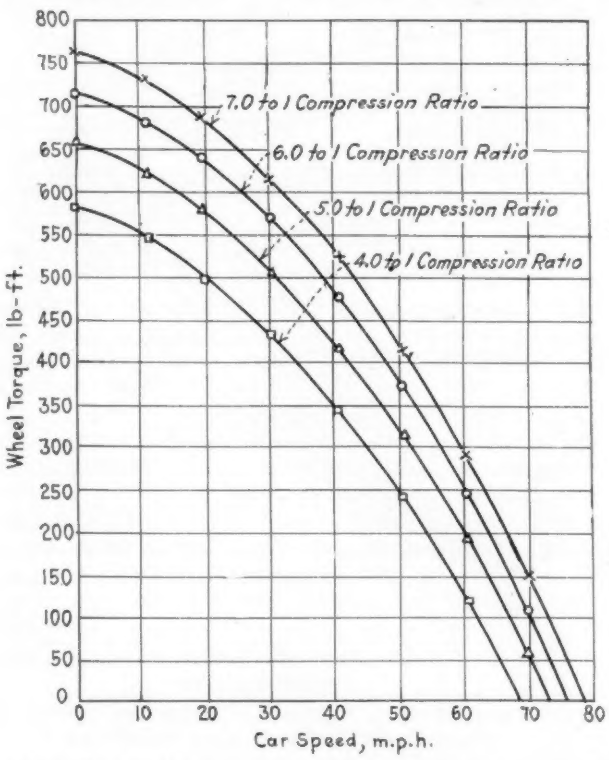


FIG. 11—HILL-CLIMBING AND ACCELERATING ABILITY OF 200-CU. IN. ENGINE WITH SEVERAL COMPRESSION-RATIOS

The Ability of Cars Increases as the Compression Ratio Is Increased; and the Top Speeds Are also Increased

lation appears. The largest engine running more slowly gives more miles per gallon than either of the other two.

The comparative curves in Fig. 10 are for four engines of various compression-ratios. The compression ratios that were selected are 4.0 to 1, 5.0 to 1, 6.0 to 1, and 7.0 to 1. The 7.0-to-1 compression-ratio is probably somewhat higher than that used on cars today. The effect on engine friction of changing the compression ratio has been found to be negligible and, if anything, somewhat less with engines of higher compression. The indicated mean effective pressure increases in the same ratio as the air-cycle efficiency.

The ability of cars increases as the compression ratio is increased; and the top speeds are also increased, as shown in Fig. 11.

As shown in Fig. 12, the miles per gallon rise with the compression ratio, but not so rapidly as I had expected.

SUMMARY OF RESULTS OF COMPARISONS

The results of the several comparisons are summarized in Fig. 13. In this figure, the percentage change

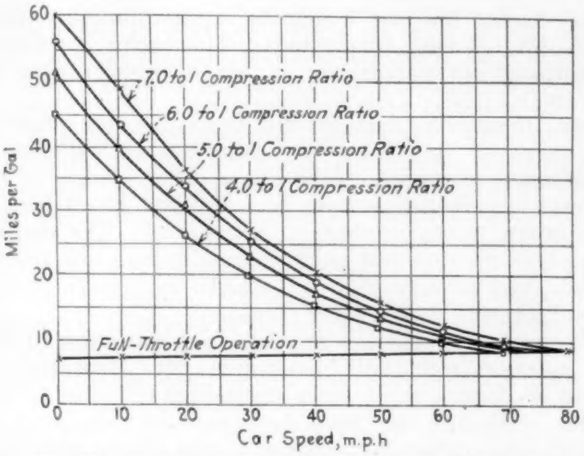


FIG. 12—MILES PER GALLON VERSUS CAR SPEED FOR 200-CU. IN. ENGINE WITH SEVERAL COMPRESSION-RATIOS

The Miles per Gallon Rise with the Compression Ratio but Not so Rapidly as Was Expected

in acceleration at 20 m.p.h., the percentage change in top speed, and the percentage change in the fuel mileage at 20 m.p.h. are plotted against the percentage change in piston displacement, axle ratio, compression ratio and car weight. A piston displacement of 100 cu. in., an axle ratio of 3.0 to 1, a compression ratio of 4.0 to 1, and a car weight of 3500 lb. have been used as the 100-per cent basis.

An increase in piston displacement of 40 per cent would correspond to an increase in hill-climbing or accelerating ability of approximately 60 per cent. A corresponding increase of 40 per cent in the rear-axle ratio would give an increase in car ability of about 42 per cent. An increase of 40 per cent in the compression ratio would give an increase in car ability of about 24 per cent. An increase in car weight of 10 per cent would reduce car ability about 10 per cent, whereas a decrease in car weight of about 10 per cent would increase the car ability approximately 12 per cent.

[2] M.S.A.E.—Assistant experimental engineer, Chrysler Corporation, Detroit.

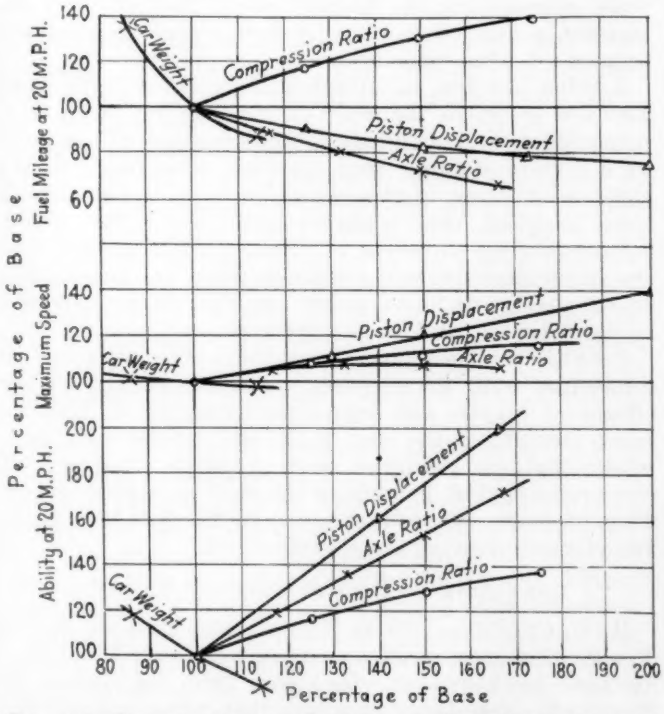


FIG. 13—PERCENTAGE OF CHANGE IN PERFORMANCE WITH CHANGE IN SEVERAL FACTORS

A Piston Displacement of 100 Cu. In., an Axle Ratio of 3.0 to 1, a Compression Ratio of 4.0 to 1, and a Car Weight of 3500 Lb. Were Used As the Basis

The same thing occurs with maximum speed. For a given percentage increase in piston displacement, the percentage increase in speed is greater than for the same percentage increase in the compression ratio or axle ratio. The effect of car weight is almost negligible, although the impression prevails among some persons that, to increase the top speed, the weight should be reduced.

Also, the change in mileage indicates that increase in the compression ratio and reduction in car weight are the two factors that increase car mileage. An increase of engine size will, however, produce less loss in miles per gallon than an increase in the engine-speed. These curves are probably the most interesting of all because they indicate what is to be expected from a given change. If it is necessary at times to increase the weight by making a change, say, of piston displacement, the corresponding loss can be estimated.

Although these curves are possibly not entirely correct, I think it would be well if absolutely correct curves could be obtained and, if possible, checked experimentally with them so far as possible.

CAN GAIN STANDARD PERFORMANCE IN VARIOUS WAYS

Many conclusions might be drawn from this plot; but I believe the most important is that the standard of car performance now taken for granted by the public can be obtained in more than one way. The particular means taken are of minor significance to the female mind that is now purchasing our motor-cars. The result is all important; just how any given set of engineers attains the desired result is not important. Very few persons who drive cars care much what the engineer thinks of them. A little of each method, tempered with other considerations, such as cost of manufacture, cost of maintenance, smoothness, good low-speed operation, and the like, will give the answer demanded by the hard laws of engineering economics.

If the proportionate gains to be obtained from the several well-known methods mentioned for increasing performance can be established, engineers can more easily strike the correct economic balance in each particular case. This is true engineering. It is absurd for engineers to be slapping at mosquito-like arguments on high speed versus low speed, high compression versus low compression, large engines versus small engines, and the like, instead of hunting the lions of total economic cost to the public of the kind of transportation it wants. If your house caught fire and burned down, because, when the fire department came, all the firemen gathered around one fire-hose which they thought was the best hose, and did not use other hose or even the hand-extinguishers, what would you think of the fire department? Performance is the house, which belongs to the public; it must be protected against the fires of cost by every means at hand, each used to its best advantage.

THE DISCUSSION

J. B. MACAULEY[3]:—The reason that high compression is of paramount importance to engineers is that it involves cooperation between the petroleum industry and the designers of automobiles. High compression is the

only factor that, on Fig. 13 shown by Dr. James, was consistently above the line in every case. In other words, when compression can be increased, a gain is made in every phase of performance. When the other factors are varied, the curve goes below the line and shows a loss in one phase, partly offsetting the gain in the others. The factors that influence the allowable compression are (*a*) the antiknock value of the fuel; (*b*) the engine design, which covers combustion-chamber design and the volumetric efficiency that can be expected from the engine; and (*c*) the temperature of the charge, which also is influenced to some extent by engine design.

The mechanism of combustion-chamber design is fairly well known. Certain gains can be made; a certain amount of possible roughness may be introduced; but, by careful design, a gain in compression can be attained without increasing the roughness.

The volumetric efficiency generally is dictated by other factors than detonation. The same thing is true of the temperature of the charge. The real determining factor, then, of the compression ratio or the compression pressures that we can use today, is the fuel.

The corporation with which I am connected has taken a step forward in bringing out its own high-compression cylinder-head, and we have made the greatest advance that we could make with fuels that are commercially available, with a view to setting some sort of definite mark toward which the automotive industry and the petroleum industry can work. Enormous developments in fuel products have been made in the last few years, but, if engineers are to take advantage of them, work must be directed toward some sort of standard of antiknock value.

High Compression Wanted Despite Premium Fuels

We have made an effort in that direction. We may be too high; we may be too low. The main thing is to crystalize the efforts of the petroleum industry into producing a better gasoline that will enable higher mean effective pressures to be obtained. Compression ratio, unlike engine size, costs nothing. Temporarily, antiknock fuels are being sold at a premium. I feel that the premium is fully justified because it contributes to the general welfare by enabling us to produce a more efficient engine. The public, in other words, in paying more for gasoline during this development period, is paying part of the cost of the development of better fuels and better engines.

We have not encountered any particular resistance from the cost angle on the part of most of the persons who have bought our high-compression engines. The last figures I have had since the announcement that a high-compression head was available for the cars show that more than 60 per cent of the cars that have been shipped have been equipped with engines having the high-compression head.

Considerable cooperative research will be required before the real basis of knowing exactly how fuels can be utilized to the best advantage will be reached, but meanwhile we have a bench-mark to guide us and we feel that the fuel companies are having a chance to pay for the extensive research that will be necessary before we can get a closer approach to the ideal fuel.

E. D. HERRICK[3]:—The experimental work we have done during the last 8 months agrees almost entirely with Mr. James' conclusions. Our work as engine manufacturers necessarily is not so much along the car line.

Mr. James has brought out the two most outstanding ways of improving car performance without increasing engine size. Like many other things in this industry, these things have been brought about because "necessity is the mother of invention." The demand nowadays for excellent performance at both low and top speeds, and at very high top-speeds, has caused engine manufacturers to do some thinking.

We have attacked the problem in a somewhat different manner from that followed by Mr. Macauley, because we have a much more diversified clientele to deal with. Although we have done considerable work on compression ratios up to 6.0 to 1, our efforts have been directed more toward increasing the volumetric efficiency of the engine. We have obtained some very surprising and pleasing results, which have shown that the compression ratio in one of our engines could be increased without increasing its size, and, by a very slight increase in the compression ratio, an increase in horsepower of just a little less than 30 per cent could be obtained. This perhaps does not speak well for the old design. This old engine, however, was comparable with other engines of its size, and our recent work has made it possible to effect this increase by doing most of our work on volumetric efficiency.

Changed Torque Peak without Changing Timing

One of the most interesting developments was that we were able to change the peak of the torque with absolutely no change in the engine timing. This was the first time in my experience that I have ever been able to shift the peak of the torque by manifolding.

The testing work that we have done indicates that, when approaching the higher speeds that are now demanded, a decided increase in horsepower is necessary because of wind resistance.

I think our line of attack still leaves us with some distance to go in the way of compression ratio, but, inasmuch as a great number of our engines will be used by a certain clientele that does not wish to go to the expense of using higher-priced fuels of the antiknock type, we shall have a chance to do some further developing in the direction of efficiency, for we feel that the fuel companies will gradually place antiknock fuels on the market at lower prices and that these fuels will be used more generally as time goes on.

Perhaps the most interesting thing we have noted in connection with manifolding was with regard to the effects of single and duplex carbureters. I hold no brief for either, but our work has proved very definitely that, in changihg from a single to a duplex carbureter, a shift is made in the peak of engine torque. This, of course, is brought about by the fact that there are virtually two separate carbureters.

Too Prone to Follow "Ground Rules"

H. M. CRANE[4]:—I think it is a shame that we do not do a great deal more of the sort of work that Mr. James has done in this paper. He comes from the Bureau of Standards. One thing on which they never standardize much at the Bureau of Standards is intellects. Their minds are always open and always shifting. One of the criticisms we can justly charge against the engineers of the industry is that, in the rush of preparing

[3] M.S.A.E.—Assistant chief engineer, Lycoming Motors Corporation, Williamsport, Pa.
[4] M.S.A.E.—Technical assistant to the president, General Motors Corporation, New York City.

for new work, they are too prone to accept some particular "ground rule" as something already determined. It is much easier to design an engine if you begin by assuming that it must have a certain bore-and-stroke ratio, or some other detail of that kind. It means one less thing to be considered. It is a dangerous trend of mind to get into, because a bore-and-stroke ratio that is very good for one purpose, or a number of crankshaft bearings that is proper for one purpose, may not be at all suitable for some other purpose.

Several companies in the industry are clamoring about large numbers of bearings. When Lindbergh flew to Mexico City, his engine had only two bearings. He had another crazy thing, nine cylinders. Whoever heard of nine cylinders in a motor-car engine? We used to have four; then some persons thought they should have six; others proved conclusively for a while that they should have 12. Now we have backed up a little, but in England they have begun building 12-cylinder engines, and we are told here that they are leading us a long way in engine design.

We Do Some Funny Things

It is unfortunate that certain things in engine design have been unduly prominent. In Great Britain they have adopted a rule for determining horsepower for taxation purposes which was the same that was adopted by the Society. It was based on an assumption, possibly very reasonable at the time, that certain maximum piston-speeds were all that could be used in an engine and that the size of the engine, therefore, was largely a question of the diameter of the cylinders and the number of cylinders. They attempted to tax the engine size, but of course they made a bad fizzle of it. We have been doing the same thing here in racing-cars. It is very funny to see racing-cars at Indianapolis rated on a piston-displacement basis, with no limitation on the speed of the engine, no limitation on supercharging, and even with permission to use two-cycle engines. The motorboat people do many funny things, but nothing like that; they always penalize a two-cycle engine in a piston-displacement race.

Such "ground rules" laid down about engine performance at different times resulted in an engineer's being praised for the number of horsepower he could get per cubic inch of piston displacement. It may be a fine thing to do. Far be it from me to say that it is not a good thing to do under certain conditions. In England it is an excellent thing to do, and in Indianapolis it is an excellent thing to do. In a commercial motor-vehicle it may be a very dangerous thing to do.

Mr. James has told you truthfully that the only question in the mind of the public today about a motor-car is what it will do in the way of transportation, that is, after the appearance of the car has been assessed, because apparently buyers like a car that looks well even without the transportation. Engineers have succeeded in giving both remarkable transportation and appearance. It makes no difference to the owner, really, though it is hard to convince a man who lives in Detroit of that fact, how many cylinders a car has. The men who are in the center of the industry become so much interested in technical details that they find it hard to believe that other persons are not so much interested.

I like to tell a story on the General Motors organization because it happens to be true and is an interesting case in point. A man who is a permanent fixture in the New York office asked me one day, "How many cylinders has the LaSalle? We had quite a discussion about it the other day. One fellow said he thought it was a V-eight but he wasn't sure." That is what the clerical people in the company think about the engine. If they, who are close to the business, think that, what does the public think?

Therefore, the thing that is important is to give performance in the best way that you can on the basis of first cost and permanent lack of trouble afterward, lack of trouble being more important, really, than the cost of correcting the trouble. It is the time taken that counts. I have been driving a car myself this summer when my chauffeur was out of business. It has not cost me much to go to a service station; the car was a low-priced car; none of the charges was high; but I hated to have to drive it down and leave it there. That is a very important thing to the owner of a single car.

I have given a good many reasons why we ought not to do various things; I think I ought to give a constructive idea of the way we ought to go about finding what is the best engine for a motor-car. Fundamentally, what we try to do with any size of motor-car is to produce the best over-all result from a given quantity of material. An engine, for instance, consists of so many pounds of cast iron, so many pounds of rather low-grade steel, and usually a few ounces of higher-grade steel. We have taken that and produced a result. Can we, by rearranging the same material in a different form, produce a still better result? It has been plainly shown in the last few years that we can. It has been done in the General Motors Corporation; it has been done outside that corporation. It is no one's pet trick. Unfortunately, the enormous cost of tooling-up for an engine again emphasizes the advantage of getting more out of a given set of dimensions. After all the boring-mills and the other machines that go to produce an engine have been set up, we find that usually the best thing we can do, while the sales department calls for more performance, is to try to speed-up that particular engine. I think Mr. Kettering was the man who said that 1925 was the year of the reamer, the year in which all cylinders were bored out larger. Usually a certain amount of reaming can be done before the water-jackets become non-existent.

Should Go Back and Study Fundamentals

Ability to cut corners in that way has been very important to the engineer and, when he comes to make up a new job, it tends to cloud his judgment with regard to what is the right thing to do; and when one's judgment becomes clouded by too much hard work along certain lines, too much "bug killing," it is a fine thing to do what Mr. James has done, to go back and study again the fundamentals; and it cannot be done too often. There are a great many things that we ought to know and continue to know, but unless we put them down on paper and look them over again, we cannot be sure that we are really right or that what we remember as being a fact is a fact. That is as true of testing as of everything else. I think it is very desirable not to have a routine set of performance tests, because we are apt to make certain tests over and over again that mean little or nothing.

Speaking of performance, as brought out in Mr. James' paper, we have another very difficult thing facing us; namely, that certain features of performance are very easy to measure. High speed, hill-climbing ability,

acceleration, and things of that sort are extremely easy to measure; many other things are not. Smoothness of operation, length of life, and such things, cannot be measured. In the General Motors Corporation, during the last 3 or 4 years, we have tried to find some way of measuring some of these details, but we know of no way that is as good as getting the average opinion of a large number of men; and that method, after all, is hard to use, compared with the measuring-stick of actual performance on a hill or on a speedway.

Better Performance Comes from Larger Cars

I am ready to admit, indeed I am proud of the fact, that engineers during the last few years have got a great deal more out of engines, but the greatest improvement in car performance has come from the fact that the cars are larger. The old days of yacht racing for the America's Cup go back to the Columbia and even farther. For years the cup races were held under a given measurement rule. Whenever a challenge was received from England, a new boat was built, and that boat proved to be faster, under the measurement rule, than the old boats. The fact is that the Reliance was from one-third to one-half as large again as the Columbia, because more clever use was made of certain factors. She had much larger sail area, much greater weight, much greater over-all length, and although she had to give some allowance to the Columbia, she could easily beat Columbia; she was a great deal larger boat and cost one-half as much again to build.

It is much easier to produce high speed in a large car. In fact, a large car naturally has higher speed than a small car; it has a much larger engine. It should have, because the engine should have some relation to the weight, whereas the wind resistance does not begin to bear the relation to the weight in a large car that it does in a smaller car. We have the same tread, nearly the same height, and most of the other factors. That has meant that cars have become larger and larger. We see that today in the latest Ford car. The new Ford car is much larger than the old car. To be built at the same price, it must be built a great deal more efficiently than the old one.

What we as engineers must do eventually is to find some way of increasing the performance without continually increasing the size; and that will be a tough job. I think I can see ways of doing it but they will not be easy; yet we must do it or must finally tell the public that we have about reached the end of this particular line of development. I do not think the public will be quite so much upset as some persons think that they will be.

Effect of Vaporization and Charge Temperature

R. W. Davis[5]:—Has the greatest feasible compression-ratio any relation to the degree of vaporization of the gas?

Dr. W. S. James:—The state of the gas, so far as its vaporization is concerned, has no effect on its usable compression. That, I believe, has been demonstrated by the work of Mr. Ricardo, in England, and of others in this Country.

Mr. Macauley:—The temperature of the charge seems to be fairly critical for detonation. If sufficient heat is added to the charge to vaporize it fully, the charge temperature rises, and we are restricted to a somewhat lower compression-ratio. Completeness of vaporization without change of temperature is something that we have not been able to investigate.

A Member:—I think Mr. Macauley made the statement that the fuel manufacturer bears the cost of the extra price of gasoline for a high-compression engine.

Mr. Macauley:—I think you misunderstood me or that I did not make myself clear. What I said was that we have had very little resistance from the public that is paying a premium for this fuel, and that this fact is helping the fuel manufacturer pay the cost of the development of antiknock fuel. In other words, one would think that when we offered, as optional equipment, a high-compression cylinder-head which required the use of a fuel that sells at a considerable premium, there would be considerable resistance. As a matter of fact, our figures on the proportion of cars that have been shipped with the high-compression head, which is optional and in some cases optional at an extra cost to the user, show that the question of fuel cost is very seldom raised.

Uneven Distribution Reduces Knock Tendency

Neil MacCoull[6]:—Mr. Davis asked a question about volatility. I should like to mention a few points that were brought out in some recent experiments even though they are probably rather well known. As the mixture ratio that is supplied to any one cylinder is changed, the tendency for the fuel to detonate varies. The mixture ratio giving approximately the maximum horsepower at the most economical setting is the one that gives the greatest detonation; otherwise, it is the mixture ratio that is normally preferred. If the mixture ratio is made either richer or leaner, the tendency to detonate is decreased. In other words, if an engine is subject to a moderate amount of detonation, the detonation usually can be decreased by enriching the mixture, provided there is a dash adjustment of the mixture ratio. If, in a multi-cylinder engine, the fuel is not completely vaporized, the distribution will be uneven, some cylinders having more, others less, than the quality of mixture desired. This will mean that the charges in the cylinders will detonate less than if all the cylinders had exactly the right mixture-ratio.

These facts have been brought to our attention in comparing the detonation value of fuels in single and multi-cylinder engines. In multi-cylinder engines, if a fairly non-volatile fuel is used, the antiknock value apparently will be higher than would be indicated by a single-cylinder engine. We shall have to use single-cylinder engines, I think, for laboratory measurements of the detonation value of fuels, because it is the only way we can eliminate the one uncertain variable of cylinder distribution. We must not overlook the fact that almost all the fuels we are now studying in the laboratory in single-cylinder engines will be used ultimately in multi-cylinder engines. If the manifolds of the engines are not hot enough for dry mixtures, the engines may seem to have less tendency to knock than they would if a little more heat were added in order to give a dry mixture.

S. G. Harris[7]:—Has Dr. James noticed any effect on the horsepower developed in high-compression engines as the oil temperature increases?

[5] M.S.A.E.—Mechanical engineer, Ashley & Johnson, Brooklyn, N. Y.

[6] M.S.A.E.—Automotive engineer with research duties, Texas Co., New York City.

[7] Jun. S.A.E.—Sales engineer, Moto Meter Co., Inc., Long Island City, N. Y.

DR. JAMES:—No, I have not. Do you mean that increasing the oil temperature has an effect on detonation?

MR. HARRIS:—Not necessarily on detonation. We have found that the oil temperature increases with increase of the compression ratio.

DR. JAMES:—Because of the engine friction due to reduction of the oil viscosity, yes. But there again you need not have an increase in the temperature of the oil with a rise in the compression ratio unless the blow-by is increased and the ring seal is insufficient. I doubt whether it is necessarily true that the oil temperature will rise as the compression ratio rises, but unless the rings are changed it may do so, because of the blow-by.

QUESTION:—Does a high-compression engine tend to decrease or increase the formation of carbon? Is not the same quantity of carbon more detrimental in producing roughness in a high-compression engine?

MR. MACAULEY:—We have found the rate of carbon formation in a high-compression engine to be little different from that of a low-compression engine. Naturally, the smaller the combustion-chamber is, the more effect a given carbon accumulation has. However, within the working ranges with which we are dealing, we have found a tendency, particularly when operating on wide-open throttle, for the fuel to burn possibly a little cleaner. On hard driving on our test cars, the period for carbon cleaning seems to remain reasonably constant. Carbon formation has a rather serious effect when the detonation point is approached, that is, by providing local hot-spotting in the cylinder; but, assuming that the factor of safety is the same, between the high-compression fuel and the compression ratio at which it is operated, that it is between the standard fuel and the lower compression-ratio at which that is operated, I do not think a great deal of difference exists.

QUESTION:—Does not the high-compression engine deposit less carbon than the low-compression engine?

MR. MACAULEY:—It seems to burn a little cleaner, particularly under hard driving. In other words, on test cars, the periods when we find that carbon accumulation becomes objectionable seem to be about the same.

WHERE THE OIL INDUSTRY IS REMISS

DR. JAMES:—With reference to low and high-compression fuels, I do not think the oil industry has done anything yet for high-compression fuel. It has sold tetraethyl lead, but that is not an oil-industry product. As I recall, tetraethyl lead was developed in the automotive industry. When the oil industry wakes up to the fact that it is a chemical industry, the knowledge probably will do some good.

As to the cost of high-compression fuel to the motoring public, I think that Mr. Macauley's statement that no objection has been raised is probably an answer to the fact that it has not cost the public any more. It pays more for the fuel, gets more mileage, and breaks about even in the long run. That again brings up the point that I have tried to make tonight, which is that what we want to do is to reduce the total cost to the public. That means not only to use to better advantage the same pounds of metal that are in the engine, but to make their use by the public cost less. If we get off on detailed discussions of one or more particularized lines of attack, we lose sight of the whole general picture. We all would be better off if we could get a general picture clearly in our minds of at least the few things we know about now, then forget them, and take up some of the other things that are as yet only in the minds of the unknown, but they are there and we must clear them up.

Road Work Under Federal Aid

FEDERAL-AID road projects completed during the fiscal year ended June 30, 1927, increased by more than 8300 miles the mileage of improved roads in the Federal-aid highway system, and brought the total length of roads with Federal assistance up to 64,209 miles. The Bureau of Public Roads also cooperated with the State highway departments in secondary improvements, necessitated by increased traffic, on 1376 miles of road. Federal payments during the year amounted to \$81,371,013.03, or about \$6,000,000 less than the disbursement of the previous year, which in turn was \$8,000,000 lower than the year before. Commenting on the Federal payments, Thomas H. MacDonald, chief of the Bureau, in his annual report to the Secretary of Agriculture, says:

> It may be expected that the annual expenditure will be still further reduced in the future until, the accumulated balances of earlier appropriations being expended, the program of expenditure reaches the rate set by the annual authorization of \$75,000,000 of recent years. The annual highway bill of the Country is in excess of \$1,000,000,000, including all expenditures of the Federal, State, county and other local governments, for construction, maintenance and administration. Of this amount the Federal expenditure is less than 8 per cent, and the States alone spent, of their own funds, more than six times the amount they received from the Federal Government.

Cooperating with the States, the Bureau completed the selection of the principal transcontinental roads which will form the United States highway system, and on which uniform signs and markers are to be erected by the States. It also practically completed the distribution to State highway departments of the surplus war material, and retains only a comparatively small quantity of explosives, which will be distributed this year.

The Federal-aid highway system now includes more than 185,000 miles of road, about one-third of which has been improved with Federal assistance. With the exception of about 7500 miles, all the 64,000 miles have been improved in the last 6 years. Regarding traffic, Mr. MacDonald observes:

> The number of motor-vehicles continues to increase annually at an approximately constant rate. The registration of 1926 was more than twice that of 1921, the year in which the Federal-aid system was designated, and the traffic served by the roads has, of course, increased proportionately. It is necessary, therefore, not only to extend the improved mileage, but also gradually to raise the type of improvement on the roads already constructed.

—Office of Information, Department of Agriculture.

Standardization Activities

NEW DUPLEX-CARBURETER FLANGES

Dimensional Specifications for Five Standard Sizes Developed by Subdivision

In the December issue of THE JOURNAL on p. 652, under Standardization Activities, reference was made to the work that was being done on the subject of duplex-carbureter flanges by a Subdivision of the Engine Division. Since the publication of this item, the Subdivision on Carbureter Flanges met in Detroit on Dec. 6 to discuss a proposed design based on the present S.A.E. two-bolt type of single mounting.

In this design two adjacent single mountings had been consolidated to make a four-bolt duplex mounting. It was found that, while this type provided accessibility to the bolts, it was objected to on the ground that it necessitated lengthening the neck of the carbureter to provide for idler adjustments on air-valve types of carbureter. Because of the small amount of room available for installation of the carbureters in many instances, this was a decided drawback and further consideration of this design was abandoned in favor of the design now in use by two of the major carbureter manufacturers.

The majority of duplex carbureters in use at present are mounted by means of a six-bolt flange, which in many installations requires the use of special wrenches for the back bolts and in some instances for the end bolts. After consideration, it was decided to recommend a four-bolt mounting based on this six-bolt mounting, as the four-bolt mounting is adequate in most cases. The design is shown with the two center holes indicated by dotted lines as an optional construction. The distance between centers of the center holes has been increased by ⅛ in., so that, when used, the bolts will be readily accessible.

In those sizes where the wrench clearance has heretofore been insufficient the holes have been moved 1/16 in. away from the barrel in two directions to eliminate the need for special wrenches.

Present practice with regard to barrel spacing has been adhered to with the exception of the 1¼ in. size, in which the spacing between the barrels has been increased, as heretofore this has been too narrow and out of line with the spacing provided in other models. A note will be added to the specification as follows:

> *Note.*—Six-bolt flanges are optional on the 1, 1¼ and 1½-in. sizes, but are recommended as necessary on the 1¾ and 2-in. sizes.

The specifications as illustrated, with this note, will be submitted to the next Engine Division meeting for discussion and approval if satisfactory.

SPEEDS OF DRIVEN MACHINES

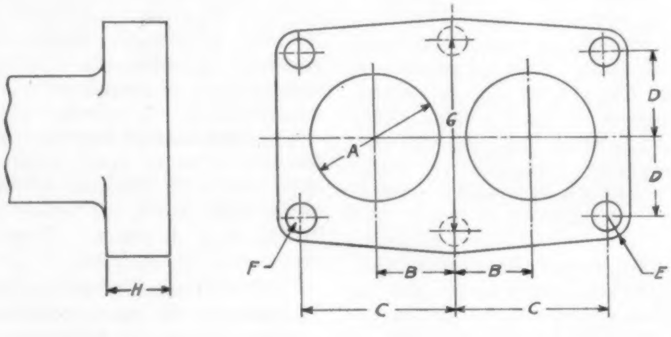
Conference on Standardization Held To Inaugurate Committee Program

At the invitation of the American Engineering Standards Committee, of which the Society is a member body, a general conference of industrial and other interests was held in New York City on Dec. 9 to discuss the feasibility of standardizing the speeds of driving and driven machinery as related to various types of motor drive, line-shaft drives and the speeds of driving connections on machine-tools, blowers, heating and ventilating equipment, hydraulic machinery, hoisting and conveying apparatus, rolling mills, printing machinery, paper mills, and so on.

The Standards Department of the Society, to which an invitation to attend the conference had been extended, circularized the members of its Production Engineering committees for comments and opinions in connection with the project. The great majority of the replies favored at least a further careful study of the project and indicated the opinion that at least something might be accomplished.

The conference on Dec. 9 was attended by about 30 representatives of a number of engineering societies and trade associations, the Division of Simplified Practice of the Department of Commerce and a few commercial companies. It was decided by the conference that the project should go forward under the procedure of the American Engineering Standards Committee and that a Sectional Committee be formed under the sponsorship of the American Society of Mechanical Engineers. A temporary Special Committee of five was appointed to take care of any matters requiring immediate attention that might arise before the sponsor

DUPLEX-CARBURETER FLANGES



Nominal Carbureter Size, In.	A	B	C	D	E	F	G	H
1	1 3/16	23/32	1 1/2	13/16	5/16	9/32	1 7/8	3/8
1 1/4	1 7/16	13/16	1 5/8	15/16	23/64	11/32	2 1/8	7/16
1 1/2	1 21/32	59/64	1 53/64	63/64	23/64	11/32	2 3/16	7/16
1 3/4	1 29/32	1 3/64	2 1/16	1 1/4	25/64	13/32	2 3/4	1/2
2	2 3/16	1 3/16	2 3/8	1 7/32	25/64	13/32	2 11/16	9/16

and the regular Sectional Committee are appointed. The Society will be invited to designate an official representative on the Committee who will be selected from among the active production engineering members of the Society.

AIR-CLEANER MOUNTINGS

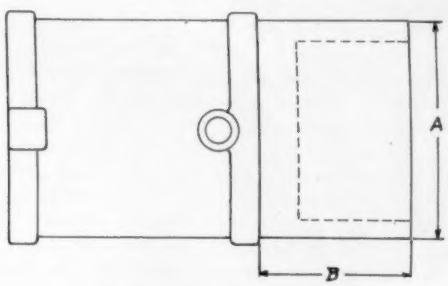
Series of Carbureter Air-Horn Dimensions Developed for Air-Cleaner Mountings

One of the subjects assigned to the Subdivision on Carbureter Flanges of the Engine Division is the development of standard mounting dimensions for air-cleaners. At the meeting of this Subdivision on Dec. 9, it was determined that the standardization of the outside diameters and the shank lengths of carbureter air-horns would automatically bring about standardization of air-cleaner attachments and clamps. It was found that there is at present a multiplicity of sizes and widths of clamps for attaching air-cleaners, and the following table of dimensions for air-horns has been suggested as suitable for approval by the Engine Division as an S.A.E. Recommended Practice.

No attempt has been made to indicate the sizes of carbureter on which the various sizes of air-horn should be used, as this is a matter for carbureter manufacturers to decide in accordance with their own ideas as to air-horn requirements. The table includes sizes larger and smaller than those used at present for the attachment of air-cleaners, but these sizes were considered necessary from the carbureter manufacturer's standpoint, as it was anticipated that sometime in the future air-cleaners may be used on all the sizes shown.

The following are the proposed specifications:

CARBURETER AIR-HORN DIMENSIONS
(S.A.E. Recommended Practice)



A	0.750 0.740	1.125 1.115	1.500 1.490	1.812 1.802	2.062 2.052	2.312 2.302	2.625 2.615	3.072 3.062	3.125 3.115
B	5/8	3/4	7/8	7/8	1	1 1/8	1 1/2	1 3/4	1 3/4

Opportunity for Individual Enterprise

IT is too frequently said that big business is closing the doors of opportunity and that the young men of today have no recourse save to hire themselves out to some corporate enterprise of large dimensions and take their place as best they can by fitting themselves to a scheme already created. Yet the mind recalls many successful enterprises, effectively competing with big business, which are the achievements of individuals who insist on going their own way. In the automobile industry, the largest combination has as its competitor the largest individual manufacturer. There are automobile manufacturers who have built their businesses from the ground up and who control them as completely as the small storekeeper controls his business. Successful foundries, machine-shops, clothing factories, textile mills, coal mines, and many other enterprises are the creation of one or a few individuals who successfully market their products in competition with large combinations of capital.

The National Industrial Conference Board announces figures showing that the average unit of business in America is still of small dimensions, easily encompassed by the creative ability of an individual. Concerning manufacturing enterprises the report says:

For the size of manufacturing establishments comprehensive information is available. For 1923, the latest year for which the census figures are available, in round numbers 45 per cent of the establishments employed 5 wage earners or less, while an additional 28 per cent employed from 6 to 20 wage earners. Again, for 1925, it was recorded that 29.8 per cent of all manufacturing establishments had products valued at from \$5,000 to \$20,000 and that an additional 36.8 per cent had products valued from \$20,000 to \$100,000, so that about two-thirds had products not exceeding \$100,000 in value. It is particularly in manufacturing that the growth of large-scale industry has been emphasized, yet, though the largest factories may produce the bulk of the product, there are obviously many lines in which relatively small-scale operations are prevalent.

Taking the business of the Country as a whole, it would appear that whatever the advantages of large-scale production may be, they are not equally obvious in all fields and that they have not dampened the spirit of enterprise or closed the doors of business to those who cannot command large capital or engage in extensive operations.

—Law and Labor.

Meetings of the Society

(Continued from p. 10)

The Production Session

The subjects of cast iron, chromium-plating and die-rolling of structural shapes will be discussed at the Production Session on Thursday evening, Jan. 26. A. R. Fors, of Continental Motors Corporation, is chairman of this session.

T. H. Wickenden, of the International Nickel Co., will present the result of research on the machinability and wearing properties of cast iron. According to Mr. Wickenden, the hardness or chemical composition of an iron is in itself no indication of its wearing properties and machinability. Iron containing a large amount of free ferrite has been found to wear rapidly, while iron containing considerable pearlite or sorbite has been found to have good wearing properties. The presence of excess-carbide spots or phosphides of high phosphorus content are found to be deleterious, due to their wearing in relief and ultimately breaking out and acting as an abrasive which scores the surfaces.

Mr. Wickenden suggests that the intelligent addition of nickel, or nickel and chromium, to an iron is a means of obtaining the correct microstructure for the combination of good wearing properties and machinability. Causes of wear in cylinder blocks are discussed, showing the desirability of securing greater hardness by the use of nickel and chromium to secure the proper structure. Since this greater hardness is, according to Mr. Wickenden, the result of a harder matrix rather than an increase in the number of carbide spots, the increased hardness is found to be a good index of the improved resistance to wear. The greater hardness has also, he states, eliminated difficulty from the valves hammering into their seats.

The analysis of cylinder blocks, pistons, clutch plates, brake drums, cams and forming dies in which nickel and chromium have been used, and the improvements secured in the performance of these parts, are also given in the paper.

Members interested in chromium-plating will welcome the paper by E. F. Baker, of the University of Michigan, outlining the results of further research on the protective values of chromium-plating. Professor Baker's paper does not minimize the usefulness of chromium in hardening surfaces, but it does expose, according to the author, some of the economic fallacies regarding the usefulness of chromium as a rust-resistant. General discussion of Professor Baker's paper will doubtlessly do a great deal to clarify the situation regarding the usefulness of chromium-plating.

The third paper to be presented at the Production Session is by W. P. Witherow, who will discuss the method of die-rolling developed by the Witherow Steel Co., of which he is president, and the application of this type of structural-steel fabrication in the automotive industry. While the fundamental method employed has been used by the company for several years, recent developments are of special interest to the automotive industry at a time when the decreasing of production costs has become the most important factor in the successful merchandising of automobiles.

Queries to Be Put at Standards Session

Should the S.A.E. Physical-Property Charts be discontinued? Should they be revised on the basis of the frequency curves outlined by E. J. Janitzky in his paper on p. 55 of this issue? Should the oil companies specify their different grades of oil by the S.A.E. Viscosity numbers in addition to their grade names so that car owners will be assured of getting the right grades of oil? Should the car companies specify the grades of oil they recommend by the S.A.E. Viscosity numbers?

These and many other equally important questions will be asked at the Standards Session on Wednesday afternoon, at which Karl L. Herrmann will preside.

Discussion of All Papers Desired

Oral or written discussion of every paper is invited by the Meetings Committee. The papers may, in a certain sense, be regarded as serving only as a basis for discussion, timely subjects having been selected with a view to eliciting the maximum discussion. A range of viewpoints is desired on every subject, the 5-min. time-limit being imposed to make this possible. Lengthy discussion, submitted prior to, during, or after a session, is included in the printed discussion of a paper, but only after the discussers have had an opportunity to revise their contributions.

Members desiring to discuss any papers should communicate with the Society, so that abstracts and preprints of papers they desire to discuss may be sent to them for study.

Tractor Meeting Deals with Uses

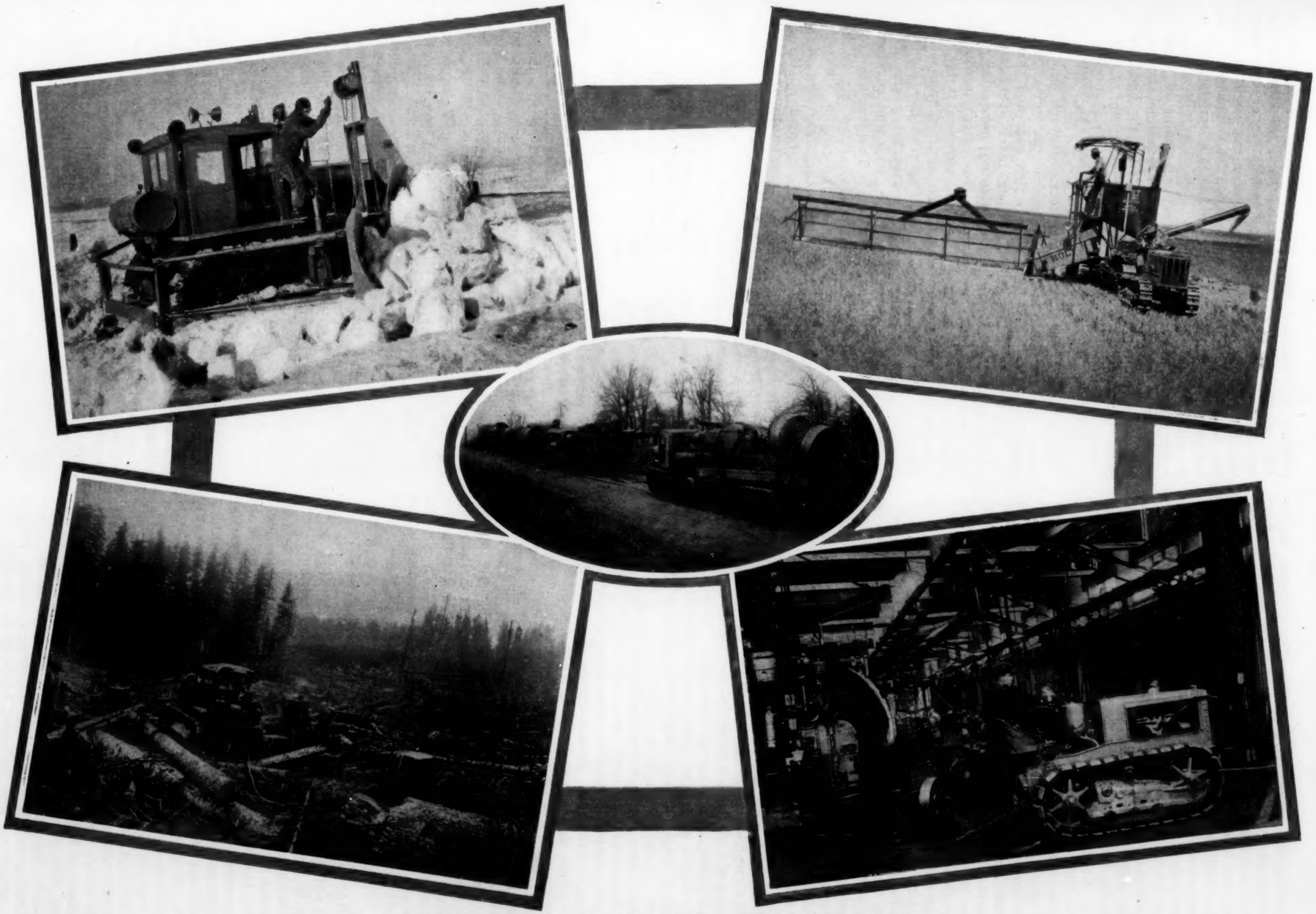
Varied Applications of Tractors to Farming, Road Building, Lumbering and Industry Reviewed and Presented Pictorially

Development of the crawler-type tractor, improvement in tractor-engine design and in farm and road machinery drawn by tractors and application of this modern automotive powerplant to innumerable uses were covered in the three papers presented at the Annual Tractor Meeting held at the Sherman Hotel in Chicago on Dec. 1 in conjunction with the 2-day annual meeting of the American Society of Agricultural Engineers, which preceded the S.A.E. session.

Prof. R. U. Blasingame, of Pennsylvania State College, gave an interesting paper on the Advance of Mechanical Power in Pennsylvania, which was illustrated with lantern slides; Otto R. Schoenrock, of the International Harvester Co., presented a paper on Power Applications of the Tractor; and L. J. Fletcher, of the Caterpillar Tractor Co., read a paper entitled The Nation's Hired Hand, prepared by Paul Weeks, of the same company, who was detained on the Pacific Coast and could not attend the meeting. The last two papers were illustrated liberally with lantern slides and motion pictures showing tractors at work.

O. W. Young, of the Hyatt Roller Bearing Co., presided over the meeting, which was attended by from 60 to 70 members and guests. Commenting on the gathering and the program in his opening remarks, Mr. Young expressed on behalf of the sponsorship a desire for a better appreciation of the importance of the Tractor Meetings of the Society on the part of executives of the companies in the industry.

Diversity of application of the caterpillar track-laying tractor, which he called "the Nation's Hired Hand," was



SOME OF THE INNUMERABLE DIVERSIFIED USES OF THE CATERPILLAR TRACTOR

(Upper Left) Opening a Road to Traffic with a Snow Plow. (Upper Right) Harvesting and Threshing with a Tractor Combine. (Center) Hauling Oil-Well Machinery on Crawler-Track Trailers. (Lower Left) Snaking Out Cut Timber with Steel Cable and Power Winches in a Lumbering Operation. (Lower Right) Moving Heavy Machinery in an Industrial Plant

the theme of the paper prepared by Paul Weeks, which was presented in the author's absence by Mr. Fletcher. The type of tractor with which the paper dealt was developed first for farming purposes in the rich drained swamp lands in California, where the circular wheels of steam traction-engines formerly used sank in the soft soil. To overcome this difficulty the traction-engine wheels had been enlarged to 9 ft. in diameter and 17-in. width of face. When the crawler track was applied, the wheels were reduced to a track that seemed ridiculously small but which carried the full weight and power of the same traction engines. Next the internal-combustion engine was substituted for the steam engine, and the ponderous steam boiler was discarded. The first gasoline-driven tractor had no change-speed gears, but later the three-speed transmission was incorporated, with all-gear drive to the tracks. The front wheel was retained for a time, until some observer of independent spirit noticed that the wheel had no real function and left it off, and "Caterpillars have learned to walk on their hind legs only, without touching their hands to the ground or using a cane," as Mr. Weeks pictured it graphically.

A most interesting thing is happening in Southwestern Kansas, where, according to the author, the country is staging a "come-back." Last summer he saw the actual disappearance of the prairie. He followed a road built with tractors as straight as a string for 150 miles and had no trouble driving at a speed of 50 m.p.h. all the way. This road was built through stretches of land that never had been plowed and other stretches where wheat was being harvested with tractors drawing combined harvesters. The prairie is raising wheat, corn, soy beans and other valuable crops at a profit by the use of tractors and the implements they draw economically. County seats are the only towns so far but good roads and the automobile make them busy marts of trade and centers of entertainment.

Formerly the roads were slightly lower than the level of the land on either side and, when a little snow had fallen and melted, anywhere else was a better place to drive than in the road. Now, a tractor draws an elevating grader, which makes a cut at the ditch line and deposits the dirt from the elevator belt in the middle of the road. The machines travel up one side and down the other, digging the ditches wider and deeper until the roadway is 60 or 70 ft. wide and each ditch about 20 ft. wide. Then, with a blade grader, the tractor spreads the dirt on the road and makes sharp, straight shoulders. A smaller tractor patrols the road for 2 or 3 months, and, as traffic develops, the surface becomes hard and smooth. As the ditches are deep and the road surface is elevated from 2 to 3 ft. above the surrounding land, the snow is blown off the road, leaving it clean and dry.

Machines Built To Work with Tractors

Road building and maintenance is a class of work which is done in a way that is little short of perfection by the tractor with which the paper dealt, according to the author, who stated that, as the power of the tractor became more distinctly realized, the tools to be hauled in road work were improved. Existing horse-drawn graders and wagons were strengthened and new tools were invented, notably the bulldozer and the automatic wheeled scraper, until now the various heavy tools make it possible to build 10 miles of road for the same cost and in the same time that 1 mile was built formerly.

The blade grader of modern strength and flexibility of control performs spectacular work when a new road is to be built where none existed before, and in rolling country, where some of the spots have to be cut down and low spots filled up, this grader does all of the work except hauling material to the fill where the distance is too great. For such hauling to fill, the wheel scraper or rotary Fresno easily gathers up the load and hauls it to the fill. The grader blade is so strong and is kept so sharp that no plowing is necessary, and when a narrow road must be widened, the blade is moved out beyond the lines of the wheels and undercuts the bank, which, after two such passes, breaks down so that the grader can work on it in the usual manner. Extensions called back-slopers can be bolted to the end of the blade, and with them the bank is smoothed at the proper angle.

Tractors are used also for hauling trains of wagons loaded with loose earth by steam or gasoline shovels in building mountain roads, and others push the loose material over the edges of fills with a bulldozer.

Farm, Lumbering and Snow-Removal Work

Many uses of the tractor in agricultural work were illustrated and described. One of these is the harvesting of grain with the tractor combine, which cuts and threshes the grain in one operation. Other farm operations in which the tractor is used include plowing, harrowing, seeding, cultivating, weeding, ditching for irrigation, hauling crops to market, cutting ensilage and pumping water.

In lumbering, also, the tractor has manifold applications. The Red River Lumber Co. has imported five Model-60 tractors which it operates 9 months in the year. These handle pine and hemlock logs 32 ft. long and varying in size from 18 to 48 in. in diameter. The tractors travel straight up the side of a mountain, stated Mr. Weeks, breaking a path for themselves through the brush and trailing two steel cables behind. Upon arriving at the cutting, the cable is looped around one end of the log and the tractor drags it down the mountain and alongside a waiting flat-car, where a derrick hoists it to its place on the car.

Another method of hauling logs is with two-wheel trailers having wheels so large in diameter and the axle so arched in the center that the largest of the logs can be raised off the ground at one end and thus moved easily over level spots. In descending the mountain side, the tractor serves as a brake to hold the load back. In some places the tractors work on slopes of 50-per cent grade.

Snow removal, which today means the wholesale cleaning of thousands of miles of highway for the use of motor-vehicles throughout the snow season, is a field in which the tractor is coming more and more into use. One marvels at the size of the push plows built on a Caterpillar tractor, according to Mr. Weeks, who stated that they stand as high as a man's head and have a spread of 14 ft., with folding wings at each side extending out 6 ft. farther. Usually they are V-shaped and have a concave surface so that they cut the snow from the road and roll it upward and outward to either side. Various inefficient designs were used for a number of years before the correct shape of this surface was evolved to give the correct rolling action. For use in cities where the snow cannot be left on either side of the streets, a huge shovel has been devised which is pushed in front of the tractor and when full is raised and dumped over the top of a truck traveling alongside.

Varied Tractor Uses in the Oil Fields

Almost the worst hauling conditions encountered in any line of work are those in new oil fields, where no roads exist and where the soil is often wet and very soft. Every new well requires more than 50 team-loads of machinery, piping and other material, and dozens of wells are started in a period of a few months. Each well has a crew of six men who must be supplied with food and other goods. Hauling activity is maintained at a high rate for 1 or 2 years, and most of the machinery and the materials is in the field before roads are built by the county. The track-laying tractor is capable of hauling six truck loads at a trip, and needs no road.

The tractor is used also for placing pipe for pipe lines, moving derricks and assisting in placing engines and

pumps. It can pull several times as hard as any machine that depends on wheel traction, and can do it on ground where a wheeled vehicle cannot be taken. Moreover, it can turn on its own center to maneuver into difficult places.

After a well has been sunk say to a depth of 3000 ft., it often has to be pumped for 10 years or more. Ordinary pumps with leather cups are suspended at the bottom of a 2-in. pipe line and operated by ¾-in. sucker rods. The cups seldom last longer than 3 months and often wear out in 2 weeks. Then the 3000 ft. of sucker rod has to be pulled out of the ground. Formerly hoist engines were used for this purpose and a boiler and derrick were required at each well, but now the tractor equipped with a winch crawls, if necessary, to the most inaccessible location and does the job.

Industrial and Military Tractor Operations

Many uses for the tractors are found in the manufacturing industries. With rubber pads fitted on the tracks they are sure-footed and do not damage wooden or concrete floors, and so are employed for moving heavy boxes and machinery and for drawing trains of carts and wagons in the machine-shops. The Model 60 is heavy and powerful enough to move locomotives in the process of building. Foundry and brick-yard refuse is loaded in dump-bottom wagons and hauled over the rough dumps to the edge, without requiring a shovel gang to smooth the way. These tractors have been fitted with direct-connected water-pumps and used to pump water from flooded cellars and from caissons; and when the electric motors of the East Peoria, Ill., waterworks were flooded last spring, a Caterpillar ran the pumps for a week. Fitted with belt pulleys, these tractors have been used to run machine-shops when the regular powerplant failed.

As military operations near the front are of necessity conducted off of the highways, and heavy guns, caissons and loads must be moved across country, the Caterpillar tractor has been adopted by the Quartermaster Department for such purposes.

This type of tractor can go where wheeled power vehicles cannot travel, can haul heavier loads, can be used for a great variety of power purposes, and saves time, labor and money.

Audience Interested in Snow Plowing

In opening discussion on Mr. Weeks' paper, Chairman Young asked whether rubber treads used on the tracks are gaining fast in usefulness and in durability. Mr. Fletcher replied that his company has had an interesting experience with the rubber treads. First was the problem of making the rubber adhere to a metal base. After this was worked out satisfactorily in cooperation with a large rubber company, came the problem of determining the fields of usefulness for the treads and their life. Under most conditions the treads last surprisingly well, in some services longer than the cast-steel shoe. Some unique uses are found for them; for instance, many cities maintain winter skating rinks and use the tractors with rubber treads for removing snow from the ice. It would be supposed that the rubber would slip, but it gives very good traction and does no damage to the surface. But on materials that are both sharp and wet the rubber will cut, as a wet knife cuts the tread of a tire casing. The rubber blocks are smooth on the tread. For a 2-ton tractor they are made about 5 x 10 in. in size. The blocks are secured to the steel castings by a sort of vulcanizing process.

Inventors with New Ideas Welcome

Chairman Young suggested that the company with which Mr. Fletcher is connected probably is approached by as many inventors working on attachments for adaptation to the Caterpillar tractor as approach the wheeled-tractor companies, and that the Caterpillar Tractor Co. has a department to take care of them. Speaking for all of the tractor companies, Mr. Fletcher said that they are pleased to have anyone consider the tractor as a power unit and that, although they are sometimes inclined to ridicule a man with a new idea, he often comes back later with a practical device and is placed in the hall of fame. Many men who wish to utilize the tractor for various purposes come to his company, which has several departments of utilization in agriculture, road building, snow removal and the like, that give considerable time to consulting with these men. The engineering department is always willing to help in working out designs for attaching equipment to the tractor. This Mr. Fletcher thought is true of all other tractor companies.

Tractors Greatly Improved

Tractors are very much more efficient today than they were before the war, and their value is being recognized more and more by farmers and industrial users, asserted Otto R. Schoenrock, of the International Harvester Co., in his paper on Power Application of the Tractor, which was illustrated with motion pictures.

The day has long since gone by when the ideal tractor was a monstrosity, ordinarily made of shaken-out castings with little machine work on them, structural shapes bulldozed into form, and bearings poured into place about cold-rolled shafts. These practices are relics of the days when engineers believed that weight was a prime factor of tractive effort.

Precision manufacture and the use of heat-treated alloy-steel parts in the fabrication of the tractors have become important factors, continued the speaker. Only by constantly improving the design and quality, and by broadening the useful application of the product in diversified ways, can the sale of tractors be increased.

Speaking of the agricultural application of the tractor, Mr. Schoenrock stated that surveys have shown that one man with a tractor can perform the field operations on at least twice as many acres of cotton as he can with the customary four-horse team, and that on a 200-acre plantation the cost of the tractor can be saved in 1 year by the economy as compared with the cost of doing the work with a team.

Many modifications on agricultural implements have been made as a result of improvement of the power take-off of the tractor, as the power to operate the machines no longer has to be furnished by the ground traction of the drawn machine.

The advantages of the inherent flexibility of the tractor have broadened its range of uses rapidly and it now rests upon the tractor engineer, said Mr. Schoenrock in conclusion, to increase this range by finding new applications and also by improving the design and durability.

Tractor Engineers Following Automotive Practice

All that Mr. Schoenrock said relative to the changes in design and construction of present tractors as compared with earlier tractors was concurred in by D. P. Davies, of the J. I. Case Threshing Machine Co., who said that he believes that new tractors will largely follow automotive practice in design, especially as regards the component parts of the engine, the front-wheel bearings and mountings, the shafts and fittings, and the use of S.A.E. steel and heat-treating. He said that he feels that the S.A.E. Handbook is used more now than ever before by tractor engineers and that all engineers engaged in tractor designing are indebted to the Society for its standardization work.

Chairman Young said that the members appreciate Mr. Davies' remarks very much, and that he thinks designing engineers in particular realize fully what the S.A.E. Standards mean to them; that the specifications for steel and other materials and other standards that have been set are used so unconsciously by engineers that their origin

is often forgotten, and that Mr. Davies had touched on a theme which all might do well to remember when using the S.A.E. HANDBOOK.

POWER FARMING IN PENNSYLVANIA

Agricultural production in Pennsylvania has been stimulated by the facts that about 90 per cent of the State's population live in the cities and towns and are engaged in the industries; that the freight rate to market is low; that there are thousands of miles of good roads, and that the market often is at the farmer's door. The industries, however, compete for labor employed on the farms and thus make it both scarce and expensive, so that farmers either are quitting the soil or are rapidly adopting machine methods of farming.

This is the general situation as pictured by R. U. Blasingame, who stated in his paper that the reports of the agricultural extension department of the Pennsylvania State College show that power and labor are the two expensive items in the cost of producing agricultural products on more than 100 farms in Lancaster County since 1920. In 1923, for instance, these two items amounted to 58 per cent of the total cost of corn production. The remaining 42 per cent included the items of use of machinery, rental of land, taxes and insurance, seed, fertilizer, and cash expenses. The cost for power and labor ranged from 21 per cent for hay production to 58 per cent for corn production; and the average cost of these items for six crops, including these and potatoes, oats, wheat, and alfalfa, was 40 per cent of the total cost.

Horse labor is charged in the reports at 20 cents per hr. and man labor at 30 cents; the differential of 10 cents is not a high premium on the intelligence of man, commented the speaker. A steady decline in the number of horses on Pennsylvania farms from 506,000 in 1920 to 393,000 in 1926 is shown by reports of the State Department of Agriculture and the United States Department of Agriculture; and in 1925 only 7 per cent of the horses were under 4 years old and 52 per cent were 10 years old or more, which indicates that horse raising is at a low ebb.

RAPID INCREASE IN FARM TRACTORS

In 1924 there were in use in the State 18,467 farm tractors and 452,000 horses of workable age. Assuming 1 hp. for each horse and 10 hp. for each tractor, the horses provided 71 per cent of the primary drawbar horsepower available on the farms and the tractors provided 29 per cent.

Pennsylvania showed an increase in tractors from 5697 in 1920 to 18,467 in 1924, or 224 per cent, a larger percentage increase than in Wisconsin, Iowa or Minnesota.

In number of tractors per 100,000 acres of improved land, Pennsylvania ranks fourth among eight agricultural States, with 156, or 1.56 to each 1000 acres.

The total cost of operating a small two-plow tractor compared with plowing with a team, as compiled from records kept for several years by a farmer in Lancaster County, is \$2.20 per acre for the tractor and \$3.50 for the team. Of these totals the cost of man labor with the tractor is 60 cents per acre against \$1.50 with the team, and that of the tractor itself is \$1.60 per acre against \$2.00 for horse labor. An itemized record for 3 years shows the total average operating cost of the tractor was 78.8 cents per hr., while the cost of horse labor was 20.0 cents per hr., but in a 10-hr. day the tractor plows 5 acres at an average of 15.76 cents per acre while the team plows 2 acres at an average cost of 10 cents per acre. These figures are exclusive of man labor.

To show the significance of these data, Mr. Blasingame cited numerous instances of farmers who are making a success of farming with the use of mechanical power in Pennsylvania, and showed a number of lantern slides of the varied uses to which they are putting tractors, such as harvesting ensilage, spraying 16 rows of potato plants at a time, plowing-under a tall growth of sweet clover, harvesting with a combine, seeding and cultivating corn, planting beets and carrots, and various other work.

Careful records kept in 1923 and 1924 by one farmer show the cost per year of maintaining a horse on his farm was \$225 and that, by the use of tractors, he has cut his plowing cost approximately \$1.75 per acre.

In conclusion, Mr. Blasingame stated that there is a great diversity of agricultural interests in the East that require a greater variety of engineering methods than is commonly required in some of the great agricultural States of the Middle West.

IMPORTANCE OF POWER IN POTATO GROWING

Interpolating in his prepared address, Professor Blasingame remarked that about 2 years ago he went to the dean and director of the Pennsylvania State College and showed him that since the Agricultural Experiment Station was established 38 or 40 years ago most of its activity and money had been expended on fertilizers and seed, and, although the results have been excellent, the cost of these two items in the production of crops is relatively small. As a result, sufficient funds were appropriated immediately for a power and labor research project and H. B. Josephson was placed in charge of the work.

Mr. Josephson prepared a chart of 10 different crops, showing the value of the crops and the value of the acreage required for their production, and this chart showed that the two values were approximately equal for hay, wheat and oats, and that the value of the corn and white-potato crops was very much greater than that of the acreage on which they were grown. In the case of potatoes, the crop value was triple that of the land value, which accounts, said Professor Blasingame, for the enthusiasm of the Pennsylvania farmers for potato growing. In 1918, he said, the State ranked about twentieth in potato production, whereas in 1925 it ranked second. This result is due, in a large measure, to the use of about 2000 power sprayers which have been adopted in that period and which spray about 100 gal. of poison solution per acre at a pressure of about 300-lb. per sq. in. It was not until sufficient mechanical power was applied to the spray that these results were obtained.

The largest single item in the cost of potato growing, said Professor Blasingame in reply to Mr. McCray, is the picking up of the potatoes after they are dug and lying on top of the ground, the labor cost for which is about 40 per cent of the total. About 44 per cent is for labor involved in plowing, harrowing, and spraying. The picking up of the potatoes is a serious cost item. One grower spent about \$1,500 for picking up a 60-acre crop. The State Agricultural Experiment Station is now working on a device that will not drop the potatoes on the ground when they are dug, and the main problem in this seems to be the separation of dirt from the tubers.

Reports of Divisions to Standards Committee

STANDARDS COMMITTEE MEETING JAN. 25

To Be Held in Connection with the Annual Meeting of the Society

In this issue of THE JOURNAL are printed reports that have been prepared for submission to the Standards Committee and to the Society by nine Divisions of the Standards Committee since the Summer Meeting last May.

All of the reports are submitted at this time for approval after having been considered carefully by the respective Divisions and given as wide publicity as possible by publication in this or previous issues of THE JOURNAL. The reports as now presented are believed to be in acceptable form and any proposals should be only in the nature of important and carefully considered constructive changes.

Under the Standards Committee procedure, these reports may be approved as presented, amended within limitations, or referred back to the respective Divisions for sufficient reason. The action taken on them by the Standards Committee will be passed upon by the Council and the general business session of the Society, with the purpose of approving them for submission to letter ballot of the members of the Society as the final step in their adoption. The letter ballot will be counted 30 days following the Standards Committee Meeting, and the reports on which the vote is affirmative will be published in the S.A.E HANDBOOK.

Rejection or major changes in any of the reports will require that they be sent back to the Divisions that prepared them and that they cannot be passed upon again before the Summer Meeting of the Society next June. In voting on the reports at the Standards Committee Meeting, the Regulations require that only members of the Standards Committee do so.

BALL AND ROLLER BEARINGS DIVISION

PERSONNEL

H. E. Brunner, *Chairman*	S. K. F. Industries, Inc.
G. R. Bott, *Vice-Chairman*	Norma-Hoffmann Bearings Corporation
F. L. Brown	White Motor Co.
T. V. Buckwalter	Timken Roller Bearing Co.
E. R. Carter, Jr.	Fafnir Bearing Co.
D. F. Chambers	Bearings Co. of America
L. A. Cummings	Marlin-Rockwell Corporation
B. H. Gilpin	Franklin Die Casting Corporation
F. W. Gurney	Marlin-Rockwell Corporation
F. G. Hughes	New Departure Mfg. Co.
H. N. Parsons	Strom Bearings Co.
W. R. Strickland	Cadillac Motor Car Co.

BALL BEARING RADII

At the Ball and Roller Bearings Division meeting in New York City on Dec. 16, present shaft and housing fillet-radii for the small sizes in the S.A.E. Standard for the Annular, the Extra Small and the Angular Contact types of Ball Bearing were criticised as requiring too large a corner radii or chamfer and leaving too small a "land" on these bearings. It was also stated that in many cases the present radii do not leave enough surface on the bearings to seat properly against the shoulder on the shaft.

The present S.A.E. radii, as given on pp. 222 to 230 inclusive, except pp. 225 and 226, of the September 1927, issue of the S.A.E. HANDBOOK, were adopted by the Society in 1924 as the limiting shaft-fillet radii to be cleared by the bearings, the bearing corner radii not being specified in the S.A.E. tables. These radii conform to the tables of the Light, Medium and Heavy series of Annular Ball Bearing proposed for American Standard, and also informally for international standard, by the Sectional Committee on the Standardization of Ball Bearings so far as the interchangeability of bearings is concerned, but follow the proposed American Standard for the shaft fillet radii in some sizes, the bearing corner radii in others, and for still others between these. These radii in both standards progress in regular order according to bearing widths but not according to the same ranges of widths. This makes it impossible to standardize the tooling for the bearing widths and corner radii, and the Division feels that the S.A.E. Standard should conform to the proposed American Standard as a matter of consistency and to permit of standardizing the tools.

The Division therefore recommends that the present S.A.E. Standard for the tables referred to be revised with regard to the corner radii so as to specify the limiting shaft and housing fillet-radii and the bearing corner radii in accordance with the proposed American Standard tables. The revised corner radii as now recommended are given in the accompanying table for the bearing widths indicated, which cover the entire range of bearing sizes in the S.A.E. Standard for Ball Bearings. The recommendation includes the Extra Small series of Annular Ball Bearings that are included in the proposed American Standard table and also the S.A.E. Angular Contact Bearings that are made to the same mounting dimensions and limits as the Annular Bearings in the Light, Medium and Heavy series.

Bearing Widths, Inclusive,	Fillet Radii[1] Maximum		Corner Radii[1] Minimum	
Mm.	Mm.	In.	Mm.	In.
5–6	0.4	0.016	0.6	0.023
7–8	0.4	0.016	1.0	0.039
9–11	0.6	0.023	1.0	0.039
12–14	1.0	0.039	1.5	0.058
15–20	1.0	0.039	2.0	0.078
21–25	1.5	0.058	2.5	0.097
26–30	2.0	0.078	3.0	0.117
31–40	2.0	0.078	3.5	0.138
41–50	2.5	0.097	4.0	0.157
52–54	3.0	0.117	5.0	0.197

[1] The fillet radii are the maximum allowable on the shaft and in the housing to be cleared by the bearings. The corner radii are the recommended minimum for either the corner radii or the chamfer on the bearings.

ROLLER BEARINGS

At the Ball and Roller Bearings Division meeting in New York City last month, the following changes in the tables of the present S.A.E. Standard, commencing on p. 248 of the September, 1927, issue of the S.A.E. HANDBOOK were brought to attention as corrections. They are therefore reported to the Standards Committee at this time as a matter of record.

Bearing No. 2786–2720 should be 2786–2729, and the cup corner-radius r is changed to 1/32 in. Bear-

ings 3383–3320 and 6580–6520 should be omitted. The bearings shown in the accompanying table should be included.

Bearing Number	Bore	Outside Diameter	Width	Corner Radii Cone	Corner Radii Cup
74500–74850	5.000	8.500	1⅞	9/64	1/8
74537–74850	5.375	8.500	1⅞	9/64	1/8

ELECTRICAL EQUIPMENT DIVISION

PERSONNEL

B. M. Leece, *Chairman*	Leece-Neville Co.
A. R. Lewellen, *Vice-Chairman*	Chevrolet Motor Co.
Azel Ames	Kerite Insulated Wire & Cable Co., Inc.
G. D. Becker	Underwriters Laboratories, Inc.
A. K. Brumbaugh	White Motor Co.
W. B. Churcher	1928 Parkway Drive, Cleveland
Bruce Ford	Electric Storage Battery Co.
W. S. Haggott	Packard Electric Co.
C. T. Klug	Willard Storage Battery Co.
T. L. Lee	North East Electric Co.
A. D. T. Libby	Automotive Electric Association
D. M. Pierson	Dodge Bros.
F. H. Prescott	Delco-Remy Corporation
E. S. Preston	Chicago Electric Mfg. Co.
B. M. Smarr	General Motors Corporation
T. E. Wagar	Studebaker Corporation of America

MOTORCOACH BATTERIES REVISED

Division Recommends Dimensional Changes To Provide for Thicker-Plate Batteries

The formulation of the present motorcoach-battery specifications on p. 104 of the September, 1927, issue of the S.A.E. HANDBOOK was based on the ratings and dimensions of the 5/32-in. plate batteries made by various companies. Since that time the development of the ¼-in. battery-plate and the increase in demand for the thick-plate type has necessitated a revision of the specifications.

The dimensions of the thick-plate batteries are of necessity somewhat larger, although in general the present dimensional specifications cover this type of battery.

The Subdivision on Motorcoach Storage-Batteries, at a meeting held in the Old Colony Club, Cleveland, on July 18, found it advisable to recommend to the Electrical Equipment Division a revision of the maximum over-all length of batteries Nos. 24 and 26 and an increase in the maximum height of all batteries, to permit the use of stronger cases.

PROPOSED REVISED STORAGE-BATTERY SPECIFICATIONS

Battery No.	No. of Cells	Minimum Capacity at 8-Hr. Rate, Amp-Hr.	Minimum Current for 20 Min., Amp.	Maximum Over-All Dimensions, In.		
				Length[1]	Width	Height
21	3[a]	110	135	17	7⅝	10⅞
22	3[a]	129	157	19⅛	7⅝	10⅞
23	3[a]	178	225	25⅞	7⅝	10⅞
24	6[a]	88	112	26⅞	7⅝	10⅞
25	6[b]	88	112	20⅞	9⅝	10⅞
26	6[a]	104	140	32½	7⅝	10⅞
27	6[a]	118	160	34	7⅝	10⅞

[a] Side-to-side assembly of cells.

[b] Double-row, end-to-end assembly of cells.

[1] The over-all end-to-end length includes handles, not hold-down devices. The handles and the hold-down devices shall be attached only to the ends of the case. Terminals and connections shall not extend above the handles; the latter shall be the highest point.

Note.—It is recommended that where the method of installation makes the handling of heavy 12-volt single-unit batteries difficult, two 6-volt units of similar capacity be used.

Owing to the increase in battery efficiency it was found possible to recommend raising the minimum battery-ratings for most of the sizes. A new specification to cover large-size batteries was added under the number 27 to provide mounting dimensions for motorcoach builders using this type of battery.

The Division recommends the approval of the accompanying table as a revision of the present Motorcoach-Battery Specifications, p. 105 of the September, 1927, HANDBOOK.

The note with reference to the use of two 6-volt units in place of one 12-volt was approved after considerable discussion, it being felt that no definite size could be specified as the maximum for a single unit.

STORAGE-BATTERY TERMINALS

Dimensional Specifications Recommended for Approval as S.A.E. Standard

The report of the Subdivision on Storage-Battery Terminals, printed on p. 321 of the September, 1927, issue of THE JOURNAL, contained suggested specifications for such terminals, including a chemical composition and a physical test. The latter two items constituted the major points of discussion when the report was submitted to the Electrical Equipment Division meeting on Oct. 31.

Aside from multiplicity of designs, which was objected to by the manufacturers of terminals, the main difficulties experienced with terminals are breakage and rapid corrosion. It was brought out that the breakage of terminals in service was due to defective terminals resulting from bad foundry practice, which in general can be traced to the use of scrap metals. For this reason it was felt that any attempt to limit the composition of terminals to any definite specifications would restrict manufacturers too much, as it is possible, by using all new metal, to employ a more inferior composition than would necessarily be specified to assure satisfactory terminals if made from scrap metal.

The paragraph under the heading of "General Information," not a part of the specification proper, contains a note on the advised minimum copper content when a terminal is made of brass. It is also believed that the recommending of the minimum amount of copper will govern the maximum amount of zinc, the element on which the rapidity of corrosion depends to a great extent.

The opinion was generally expressed that the testing of terminals is largely up to the purchaser and that no standard test could be devised which would in all cases assure a satisfactory product. Likewise, there is a great divergence of opinion as to the relative merits of tensile-strength and bending tests. For this reason the aforementioned general information will also include a note as to the tensile-strength a suitable terminal should show.

When the dimensional specifications were brought up for approval, criticism of the 5/16-in. opening in the cable-type clamp was expressed owing to the fact that, when using some methods of assembling, cable strands slip through the opening unless the opening is smaller than specified. Therefore, to permit some users to have a slightly smaller opening, if desired, the 5/16-in. dimension was changed to read: "5/16 In. Maximum," it being felt that in the majority of cases manufacturers would adhere to the 5/16-in. dimension because of the saving of metal, if for no other reason.

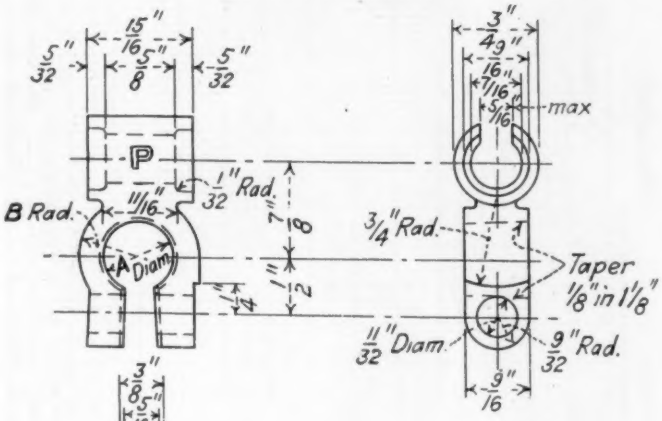
Question was also raised as to the subdivision's specification on the bolt hole, which called for a cored hole; therefore, in the final form, as approved by the Electrical Equipment Division, this is shown as a 5/16-in. hole, with no mention as to the method of forming the hole.

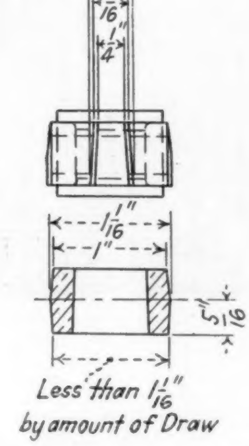
The Electrical Equipment Division recommends approval

by the Standards Committee of the following specifications as an S.A.E. Standard:

Storage-Battery Terminals

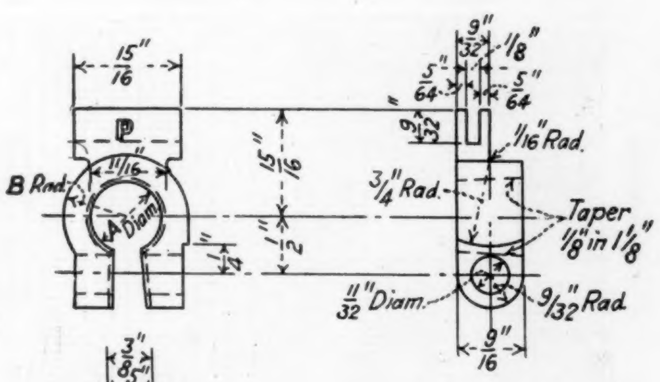
(*S.A.E. Standard*)

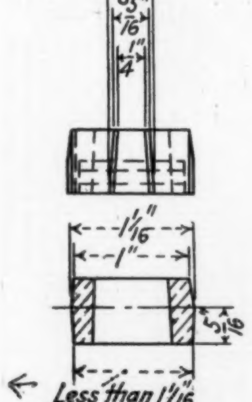




Cable Type

	A Diameter	B Radius
Positive	11/16	17/32
Negative	5/8	1/2





Strap Type

	A Diameter	B Radius
Positive	11/16	17/32
Negative	5/8	1/2

(*General Information*)

It is recommended that the minimum copper content of storage-battery terminals be 75 per cent by weight, any less amount materially shortening the life of the terminal. A satisfactory terminal should show a minimum tensile-strength between the clamping jaws of the terminal of 300-lb. direct pull on a tensile-testing machine.

ENGINE DIVISION

PERSONNEL

A. F. Milbrath, *Chairman*	Wisconsin Motor Mfg. Co.
E. S. Marks, *Vice-Chairman*	H. H. Franklin Mfg. Co.
R. J. Broege	Buda Co.
L. F. Burger	International Harvester Co.
J. B. Fisher	Waukesha Motor Co.
J. D. Harris	McCord Radiator & Mfg. Co.
C. B. Jahnke	Fairbanks, Morse & Co.
L. P. Kalb	Continental Motors Corporation
E. T. Larkin	Sterling Engine Co.
R. C. McWane	Associated Auto Engine Rebuilders
K. R. Manville	International Motor Co.

ENGINE-TESTING FORM REVISION

Present Curve Sheets Changed and New Form Added for Large Engines

Following the adoption of the present engine-testing forms by the Standards Committee in January, 1927, additional suggestions were received for still further improving the curve sheets. It was also deemed advisable to attempt to develop a curve sheet for engines of larger size than heretofore provided for. The Subdivision on Engine-Testing Forms therefore continued its investigation along these lines through the medium of a survey requesting information from manufacturers of large rail-car engines and air-plane engines and asking for samples of the forms used by such companies at that time for their large engines.

Because of the many and varied factors which the different companies wish to take into consideration when testing large engines, it is not thought possible to develop a form that will provide for the plotting of curves for all such items and, as explained later in the subdivision report, a blank form, as illustrated, has been proposed and approved by the Engine Division. [See p. 108]

The following report, submitted by F. W. Sampson at the Engine Division meeting on Oct. 25, gives the revision of the existing forms as approved by the Division. The illustrations indicate the revisions as they will appear on the final forms and also present the proposed new form D6. [See pp. 108 and 109]

Proposed Revision of S.A.E. Engine-Testing Forms

Proposed Curve Sheet D6.—It has been suggested that an additional curve sheet, D6, be drafted to cover tests of large-size miscellaneous engines. By carefully reviewing the replies from manufacturers circularized, it has been decided that a curve sheet of this suggested form would be almost impossible to draft in any usable form. In its place the Subdivision recommends the illustrated blank form, D6, for addition to the curve sheets D1 to D5 of the testing forms.

It is believed that this curve can be used by air-plane, marine, and rail-car engine manufacturers, and in addition may be used by those who would like to use the S.A.E. Forms but who, for some reason,

find the sheets D1 to D5 unsuitable for their purpose.

If the above sheet is adopted, it becomes necessary to change the word "five" to "six" in the heading of Sheet A under rules and directions of the testing forms in the sentence "(4) Curve sheets (furnished in five sheets for various size engines)".

The following changes are recommended in the curve sheets:

Change heading to side of curve sheets to provide more room for data at top.

Add "Test No." to top of curve sheets.

Change the heading on curve sheets D1 to D5 to agree with the heading on the new proposed sheet, D6. This provides for several items which have been requested and makes the curve sheets usable separately as well as in conjunction with a test.

Crowd all scales closer to the edges of the curve sheets. This gives more room for the curves.

Omit the word "Brake" in "Brake horsepower", making it possible to use this scale for friction and indicated horsepower.

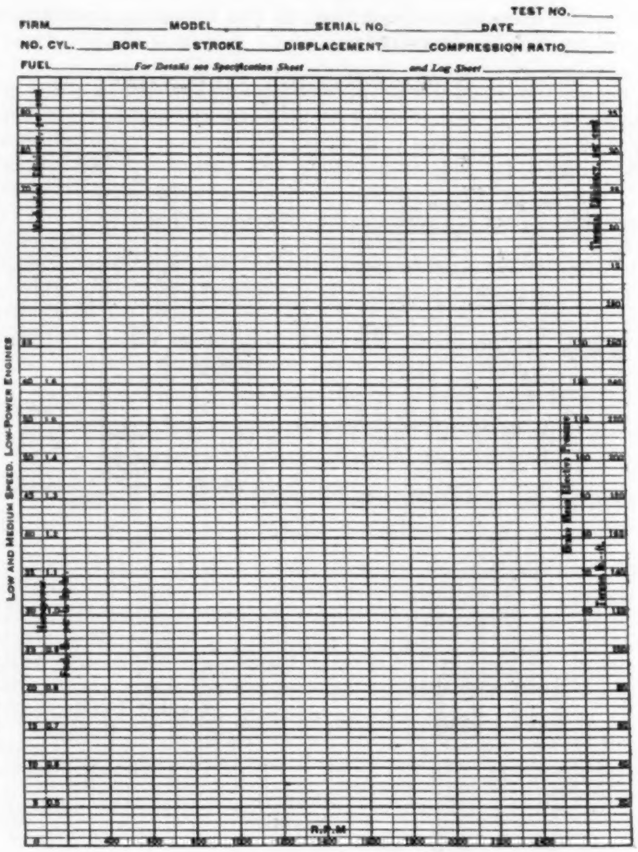
Change the method of designating curves to the following:

D1—Low and medium-speed low-power engines
D2—High-speed low-power engines
D3—High-speed medium-power engines
D4—Low and medium-speed medium-power engines
D5—Low and medium-speed high-power engines
D6—Miscellaneous speed and power engines

On Curve Sheet D2, extend torque scale to 160 and add "lb-ft." after the word "torque."

On Curve Sheet D3, change torque scale to read from 60 to 300 located vertically in the same place.

On Curve Sheet D4, move R.P.M. scale one division



S.A.E. ENGINE TESTING FORMS — LOG SHEET—C No._____

Name_____
Model_____ No. Cyls._____
Bore_____ In. Stroke_____ In. Displ. (D)_____ Cu. In.
Laboratory_____ Date_____
Observers_____
Fuel_____ B. T. U. per Lb._____ Sp. Grav._____ at_____ deg. fahr.
Dynamometer_____ Arm (R)_____ ft.
Humidity_____ per cent.
Oil_____ Grade_____ Cold Test_____ deg. fahr.
Saybolt Univ. Vis. at 100 deg. fahr._____ At 210 deg. fahr._____

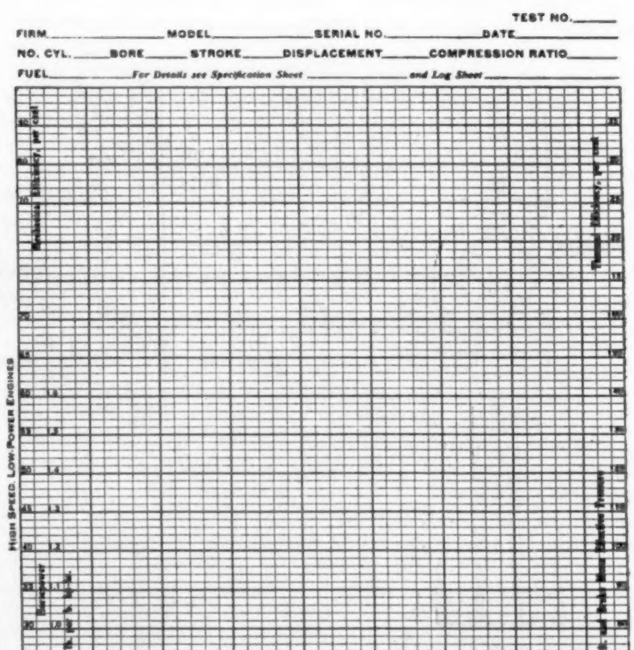
	Run Number	Symbol	Formula	1	2	3	4	5	6	7	8	9	10
Brake Horsepower and Fuel Consumption	Time Started		*										
	Duration of Run—Min.	t	*										
	Counter Start	C_s	*										
	Counter Finish	C_f	*										
	Total Rev.	r	C_f-C_s										
	Average R.P.M.	N	$\frac{r}{t}$										
	Barometer in. Mercury		*										
	Room Temp.		*										
	Correction Factor	C.F.	$\frac{P_s}{P_o}\times\sqrt{\frac{T_o}{T_s}}$										
	Brake Load at Arm R	P	*										
	Brake Load Corrected	P_c	CF×P										
	Torque Lb. Ft.	T	PR										
	Brake M.E.P.	ϕ	$\frac{150.8\,T}{D}$										
	Brake HP.	B. HP.	$\frac{PNR}{5252}$										
	Friction HP. at N	F. HP.	F.HP. Curve										
	Indicated HP.	I.HP.	B.HP.+F.HP.										
	Mechanical Efficiency	M.E.	$\frac{B.HP.}{I.HP.}$										
	Temp. Jacket Water—In		*										
	Temp. Jacket Water—Out		*										
	Temp. Oil—In		*										
	Temp. Oil—Out		*										
	Oil Press., Lb.		*										
	Temp. Air to Carbureter		*										
	Wt. Fuel Start	W_s	*										
	Wt. Fuel Finish	W_f	*										
	Lb. Fuel Used	W	W_s-W_f										
	Lb. Fuel per B.HP. Hr.	F	$\frac{60\,W}{t\times B.HP.}$										
	Thermal Eff. re B.HP.	T.E.	$\frac{2545}{F\times B.T.U.}$										
Friction HP.	Time Started		*										
	Duration of Run—Min.	t	*										
	Counter Start	C_s	*										
	Counter Finish	C_f	*										
	Average R.P.M.	n	$\frac{C_f-C_s}{t}$										
	Brake Load at Arm R	p	*										
	Friction HP.	F. HP.	$\frac{pRn}{5252}$										
	Mean Temp. Jacket Water		*										

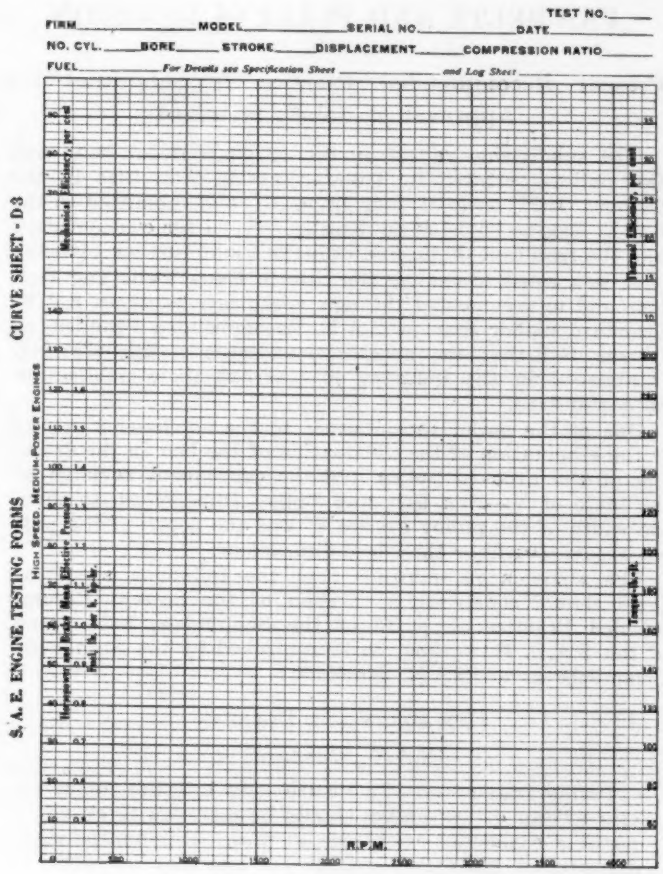
Above computed data corrected for barometer Yes / No and temperature Yes / No

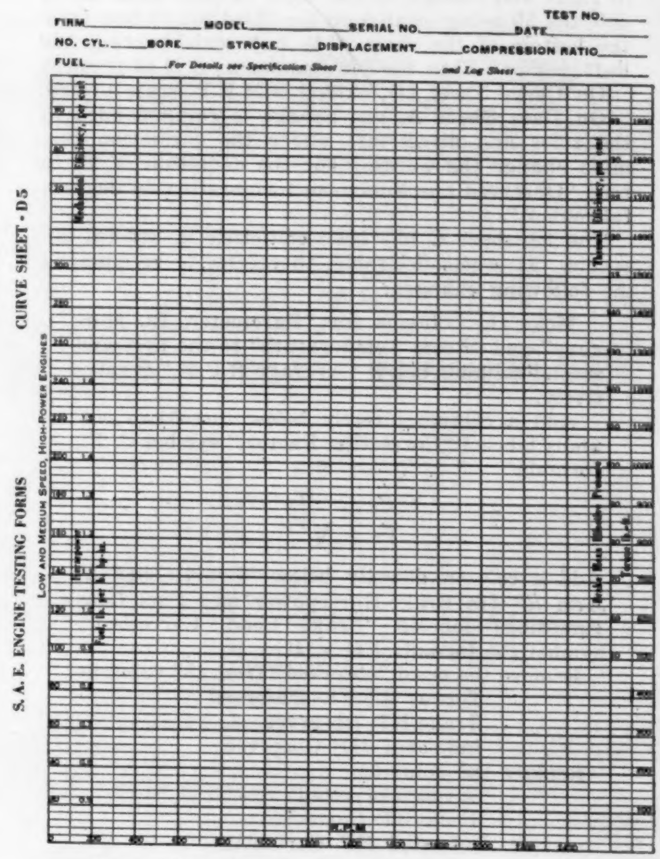
Refer to Specification Sheet No.......

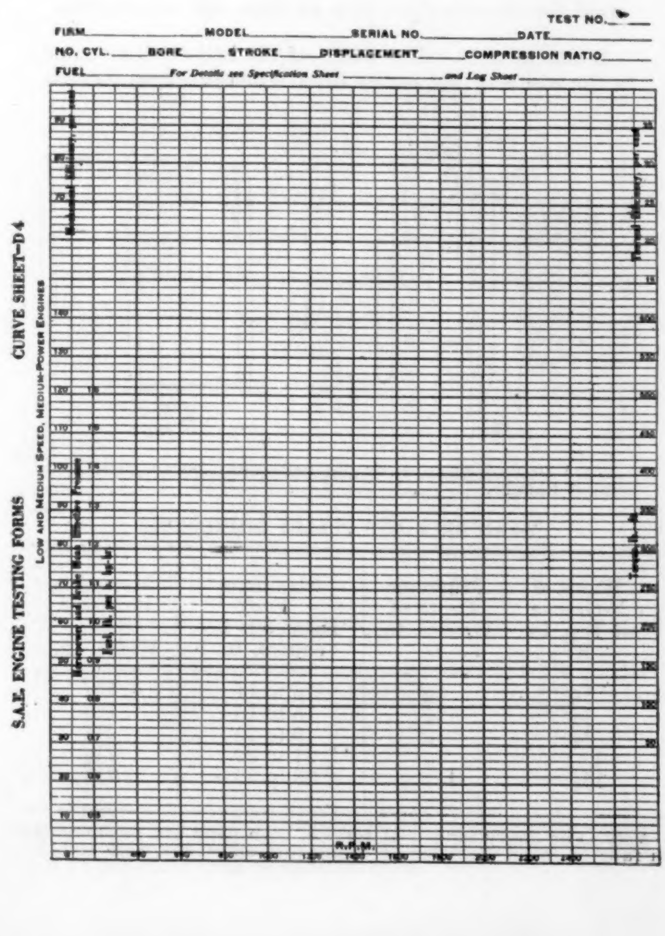
Refer to Curve Sheet No.......

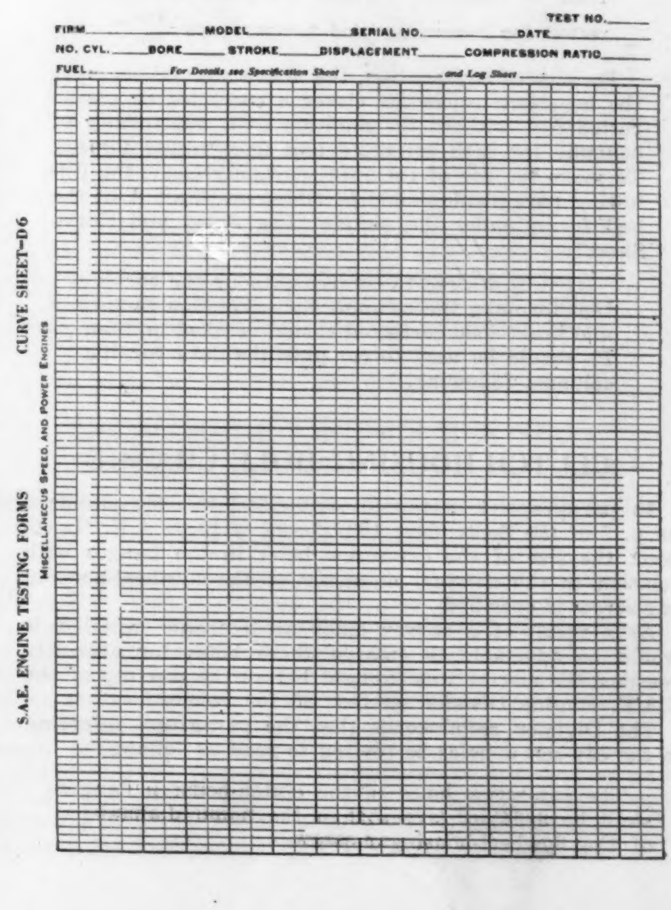
*Laboratory readings.




TEST NO.
FIRM MODEL SERIAL NO. DATE
NO. CYL. BORE STROKE DISPLACEMENT COMPRESSION RATIO
FUEL For Details see Specification Sheet and Log Sheet
S. A. E. ENGINE TESTING FORMS
CURVE SHEET - D3
HIGH SPEED, MEDIUM-POWER ENGINES
R.P.M.


TEST NO.
FIRM MODEL SERIAL NO. DATE
NO. CYL. BORE STROKE DISPLACEMENT COMPRESSION RATIO
FUEL For Details see Specification Sheet and Log Sheet
S. A. E. ENGINE TESTING FORMS
CURVE SHEET - D5
LOW AND MEDIUM SPEED, HIGH-POWER ENGINES
R.P.M.


TEST NO.
FIRM MODEL SERIAL NO. DATE
NO. CYL. BORE STROKE DISPLACEMENT COMPRESSION RATIO
FUEL For Details see Specification Sheet and Log Sheet
S.A.E. ENGINE TESTING FORMS
CURVE SHEET—D4
LOW AND MEDIUM SPEED, MEDIUM-POWER ENGINES
R.P.M.


TEST NO.
FIRM MODEL SERIAL NO. DATE
NO. CYL. BORE STROKE DISPLACEMENT COMPRESSION RATIO
FUEL For Details see Specification Sheet and Log Sheet
S.A.E. ENGINE TESTING FORMS
CURVE SHEET—D6
MISCELLANEOUS SPEED, AND POWER ENGINES

to right and change torque scale to read from 50 to 600, the 50 being located on the third heavy line from the bottom of the sheet (1½ in.) scale bearing 100 lb-ft. per in. Thus the 600 remains as it is at present.

On Curve Sheet D5, extend B.M.E.P. scale to 140.

On Data Sheet A, one change is recommended in the rules and directions: under the correction formula change the wording for the definition of T_o to read "Observed absolute room temperature in degrees fahrenheit".

The log-sheet C has been criticized in several respects. It seems desirable, therefore, to recommend the following changes:

> Move the columns for "Barometer, In. Mercury" and "Room Temperature" to the first and second columns below "Average R.P.M." respectively.
>
> Add a column directly below these two columns labeled "Correction Factor," symbol C. F., formula
>
> $$\frac{P_s}{P_o} \times \sqrt{\frac{T_o}{T_s}}$$
>
> Add a column directly below "Brake Load at Arm R" (in Brake-Horsepower and Fuel Consumption) labeled "Brake Load, Corrected", symbol P_c, formula $CF \times P$
>
> Remove the word "observed" from the columns
> Torque Lb-Ft. Observed
> Brake-HP Observed
> Indicated HP Observed
>
> Remove the columns
> Torque Corrected
> Brake-HP Corrected
> Indicated HP Corrected
>
> Leave room for five blank columns at the bottom of the brake-horsepower and fuel-consumption group
>
> Add a footnote to the bottom of the page to read as follows: "Above computed data corrected for barometer and temperature $\begin{matrix}\text{yes}\\\text{no}\end{matrix}$".

By way of explanation, the above alterations make the log-sheet usable for either a corrected or uncorrected test without the addition of a multiplicity of columns for both corrected and uncorrected figures. To make the use of the sheet perfectly clear, the following paragraph should be added on Sheet A of the test forms under the section "Log Sheet and Curve Sheet":

> If it is desired to correct data by the correction formula, the columns for correction factor, and brake-load corrected should be filled in, then P_c should be used to compute the data for the columns following.

CLUTCH-HOUSING HOLE CHANGE

In paragraph 1 of the present clutch-housing standard on p. 2 of the September, 1927, issue of the S.A.E. HANDBOOK the size of the cap-screw holes in the flanges with relation to the nominal diameter of the flywheel-housing cap-screw is specified.

As a result of a survey made to determine whether it would be advisable to enlarge these holes for assembly reasons, the matter was brought before the meeting of the S.A.E. Engine Division on Oct. 25 for reconsideration.

The Division recommends that the paragraph referring to the cap-screw holes be revised to read as follows:

> The cap-screw holes in the clutch-housing flanges shall be 3/64 in. larger than the nominal diameter of the flywheel-housing cap-screw.

FAN-BELTS AND PULLEYS REVISION

Present Recommended Practice Is Submitted for Approval as S.A.E. Standard

The subdivision report on the revision of fan-belts and fan pulleys, printed in Standardization Activities in the October, 1927, issue of THE JOURNAL, was submitted to the S.A.E. Engine Division meeting on Oct. 25 for consideration and the resultant discussion brought about further revision.

It was voted to change the title to Fans, Belts and Pulleys and to recommend the new specifications as an S.A.E. Standard rather than as S.A.E. Recommended Practice, as it was felt that the specifications were sufficiently well established in the industry to warrant their publication as a standard.

One of the major amendments to the subdivision report is the elimination of the illustration of the belt in the drawing of the grooved pulley and the consequent revision of the table of V—Fan Belt and Pulley Dimensions, to show the width of the pulley groove W and the depth of the pulley groove D rather than belt dimensions.

The Division recommends that the following specifications should constitute a revision of the present Recommended Practice on p. 13 of the September, 1927, issue of the S.A.E. HANDBOOK, to be approved by the Standards Committee as an S.A.E. Standard:

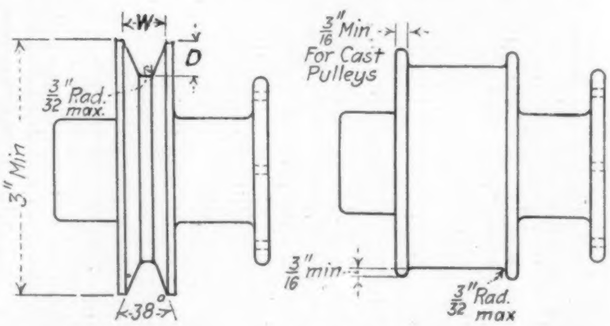
FAN BELTS AND PULLEYS

(S.A.E. Standard)

Pulley Diameters.—To insure long belt life, diameter of fan driven-pulley should be made as large as possible consistent with size of fan. Recommended diameter of fan driven-pulleys not less than one-fifth of the diameter of fan and not less than 3¼ in. in any case. Diameters of fan pulleys to be given in increments of not less than ¼ in.

Angle of Groove.—An angle of 38 deg. shall be used for driving fans only or fans and accessories.

Width of Belt.—The width of the belt shall be equal to the width of the pulley groove measured on its out-



Note: Driving pulleys for flat belts shall be crowned and without flanges.

V-FAN BELT AND PULLEY DIMENSIONS

Width of V-Groove at Top, In. W	Minimum Depth of Groove, In. D	Maximum Fan Diameters Inclusive, In.	Maximum Projected Blade Width, In.
⅝	9/16	Up to 14.	1⅝
⅝	9/16	15 to 18	1⅞
¾	11/16	19 to 20	2¼
1	15/16	21 to 22	2½
1¼	1⅛	23 to 26	2½

Note: For heavy industrial service, twin belts are recommended on fans 26 in. in diameter or larger instead of one wide belt.

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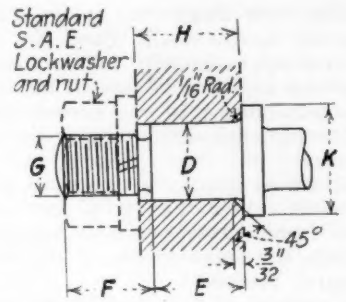
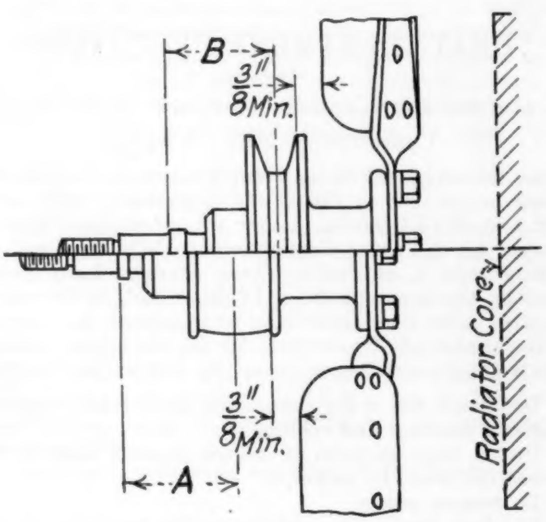


FAN-PULLEY SPINDLES FOR SOLID FAN-BRACKETS

Width of Belt, In.	*D*	*E*	*F*	*G*	*H*	*K*
1-1¼	0.748 0.746	⅞	⅞	⅝-18	1	1
1½	0.873 0.871	1	⅞	⅝-18	1⅛	1⅛
2	0.998 0.996	1⅜	15/16	¾-16	1⅝	1¼
2½-3½	1.248 1.246	1 9/16	1 5/16	1-14	2	1½

side diameter. For link-belts the next larger size pulley should be used.

Angle of Belts.—The included angle of the sizes of rubber belts shall be 42 deg. to allow for the bulging



FLAT AND V-BELT FAN-ASSEMBLY DIMENSIONS

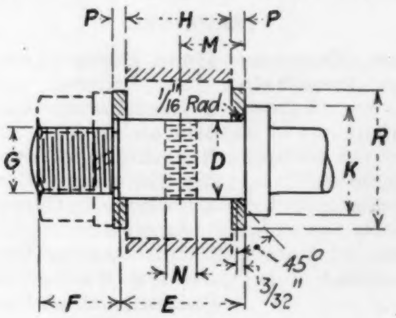
Belt Widths, In.		*A*	*B*
Flat	*V*		
....	⅝	...	1½
...	¾	...	1¾
1	1	1¾	2⅛
1¼	1¼	1¾	2⅛
1½	...	1¾	...
2	...	2	...
2½	...	2½	...
3	...	2½	...
3½	...	2¾	...

Note: When no shroud is used, front edge of fan blade shall be not more than ¾ in. from core.

FLAT FAN-BELT AND PULLEY DIMENSIONS

Belt Width, In. ±⅛	Pulley Width, In. ±0.01	Maximum Fan Diameters, Inclusive, In.	Maximum Projected Blade Width, In.
1	1⅛	Up to 14	1⅝
1¼	1⅜	15 to 18	1⅞
1½	1¾	19 to 20	2
2	2¼	20 to 22	2¼
2½	2¾	21 to 24	2½
3	3¼	25 to 28	2½
3½	3¾	29 to 36	3

Length of slot to allow for ½-in. take-up per foot of belt length.



FAN-PULLEY SPINDLES FOR SLOTTED FAN-BRACKETS

Width of Belt, In.	1-1¼	1½-2	2½-3½
D	0.873 0.871	0.998 0.996	1.248 1.246
E	1 3/16	1 9/16	1⅞
F	13/16	15/16	1¼
G	⅝-18	¾-16	1-14
H	1	1⅛	1½
K	1	1¼	1½
M	⅝	13/16	1
N	5/16-18	½-20	½-20
P	3/16	¼	¼
R	1⅜	1¾	2

of the inside of the belt when laid around the pulley. The included angle of leather belts shall be 38 deg.

Finish of Pulleys.—Driving surfaces of pulleys shall be smooth and free from tool or chatter marks.

HOOD-LEDGE LACINGS REVISED

Subdivision Develops Quality Recommendations and a New Table of Dimensions

The report of the Subdivision on Hood-Ledge Lacings, printed in Standardization Activities in December, 1926, was submitted for consideration to the S.A.E. Engine Division meeting on Oct. 25, 1927, and was approved. The specification, which is reprinted herewith, will take the place of paragraph 3 of the radiator standards appearing on p. 19 of the September, 1927, issue of the S.A.E. HANDBOOK under the heading Hood Lacings and is herewith submitted to the Standards Committee for approval as an S.A.E. Standard. The sizes proposed are in accordance with the minimum requirements given in the present specification for hood lacings.

PROPOSED RADIATOR HOOD-LEDGE LACING SIZES
(*S.A.E. Standard*)

Thickness, In.	Width, In. 3/8	1/2	5/8	3/4	1	1 1/4
1/8	X	X	X	X	X	X
3/16	..	X	X	X	X	X

When woven, material shall be made of a good grade of cotton yarn woven solidly with a fine weave. It shall not contain jute. The finished webbing shall be thoroughly impregnated with a light solution of creosote or asphaltum cut in a solvent deodorized as much as possible. The finished lacing shall be flexible and shall retain its flexibility and resiliency.

IRON AND STEEL DIVISION

PERSONNEL

J. M. Watson, *Chairman*	Hupp Motor Car Corporation
J. H. Nelson, *Vice-Chairman*	Wyman-Gordon Co.
J. R. Adams	Midvale Co.
R. J. Allen	Rolls Royce of America, Inc.
A. L. Boegehold	General Motors Corporation
Henry Chandler	Vanadium Corporation of America
J. D. Cutter	Fafnir Bearing Co.
A. H. D'Arcambal	Pratt & Whitney Co.
B. H. DeLong	Carpenter Steel Co.
F. P. Gilligan	Henry Souther Engineering Corporation
H. W. Graham	Jones & Laughlin Steel Corporation
W. G. Hildorf	Reo Motor Car Co.
E. J. Janitzky	Illinois Steel Co.
J. A. Mathews	Crucible Steel Co. of America
W. C. Peterson	Snyder, N. Y.
E. A. Portz	Central Alloy Steel Corporation
S. P. Rockwell	Stanley P. Rockwell Co.
R. B. Schenck	Buick Motor Co.
W. R. Shimer	Bethlehem Steel Co.
H. P. Tiemann	Carnegie Steel Co.
E. W. Upham	Chrysler Corporation
T. H. Wickenden	International Nickel Co.

NEW S.A.E. STEEL RECOMMENDED

Subdivision Submits High-Manganese High-Sulphur Steel Specification

Discussion at the last meeting of the Iron and Steel Division, held in Detroit on March 29, indicated the need for specifications for high-manganese high-sulphur steel in view of the extensive usage that this type of steel is finding in the industry.

A subdivision, after giving the matter thorough consideration, recommended a specification for approval by the Iron and Steel Division. The following excerpt from the minutes of a Subdivision meeting, held in Detroit on June 22, gives the reasons which led to the adoption of values of the various elements of this steel:

> It was felt that the principal demand at the present time is for a carburizing steel with a carbon range of 0.10 to 0.20 per cent. Steels of this type with high carbon-content are used to some extent, but the demand at present is rather limited. It was agreed that a range of 0.15 to 0.25-per cent carbon is undesirable for most carburizing work.
>
> It was felt that one manganese range instead of two or more is highly desirable in the interest of standardization. Little information seems to be available as to the relative machinability of the two types; namely, 1.00 to 1.30 and 1.25 to 1.75 per cent of manganese. Steels with manganese under 1.20 per cent approach rather closely S.A.E. Steel No. 1120, while steels with over approximately 1.60 per cent of manganese have been reported in several instances as deficient in machinability. It was agreed that a range of 1.25 to 1.55 per cent seems to give the most satisfactory results.
>
> It was decided to specify a maximum phosphorus-content of 0.050 rather than 0.045 per cent as the higher figure should prove perfectly satisfactory and would facilitate the manufacture of this steel by the acid open-hearth process.
>
> A sulphur content of 0.09 to 0.13 per cent was at first proposed, but it was felt that the steel manufacturers should have a range of 0.05 instead of 0.04 per cent. Considerable discussion ensued as to whether the range should be widened upward or downward. The 0.14 per cent of sulphur would tend to produce a greater number of manganese-sulphide inclusions; on the other hand, 0.08 per cent of sulphur would tend toward impaired machinability. A range of 0.08 to 0.13 per cent of sulphur was finally agreed upon. It was the opinion of the Subdivision that a 0.10-per cent minimum sulphur-content would necessitate too high a maximum value for this element.

The Iron and Steel Division recommends the approval of the following specifications for a new high-manganese high-sulphur steel to be known as X-1315:

PROPOSED S.A.E. STEEL X-1315

Element	Per Cent
Carbon	0.10-0.20
Manganese	1.25-1.55
Phosphorus, maximum	0.05
Sulphur	0.08-0.13

HEAT-TREATMENT DEFINITIONS

Iron and Steel Division Recommends Approving Joint Committee's Minor Changes

Since the approval of the Heat-Treatment Definitions appearing on pp. 274 to 276 of the September, 1927, issue of the S.A.E. HANDBOOK, a few minor changes have been approved by the Joint Committee on Definitions, of which the Society is a member. These changes have been approved by the Iron and Steel Division and, to the end that the entire Joint Committee may be in accord, it is requested that the Standards Committee, for the Society as a member of the Joint Committee, approve the following changes:

> Definition No. 4 for Annealing is to read: Annealing is a heating and cooling . . . etc.
>
> Under Note B is to be added another note to be known as Note E, namely,
>
> To remove gases.
>
> The last line under definition for annealing is to read:
>
> Certain specific heat-treatments coming under . . . etc.
>
> Under definition 6, for Case Hardening, pertaining to "case" and "core" is to be added a note as follows:
>
> These definitions refer to both case hardening and carburizing.

LIGHTING DIVISION

PERSONNEL

C. A. Michel, *Chairman*	Guide Motor Lamp Mfg. Co.
R. N. Falge, *Vice-Chairman*	General Motors Corporation
H. S. Broadbent	Westinghouse Lamp Co.
R. E. Carlson	General Electric Co.
W. B. Churcher	Cleveland

A. W. Devine	Commonwealth of Massachusetts
C. E. Godley	Ypsilanti, Mich.
D. A. Harper	Tung-Sol Lamp Works
P. J. Kent	Chrysler Corporation
A. R. Lewellen	Chevrolet Motor Co.
H. H. Magdsick	National Lamp Works of General Electric Co.
E. S. Marks	H. H. Franklin Mfg. Co.
C. D. Ryder	Cincinnati Victor Co.
W. F. Thoms	Indiana Lamp Corporation
T. E. Wagar	Studebaker Corporation of America

HEAD-LAMP LABORATORY TESTS

Division Recommends Revision of Present Specifications

Since the present S.A.E. Headlighting Test Specifications were adopted, the depressed-beam type of headlighting has largely replaced the old dimming system. This change in practice naturally brought about a new situation to be met by State regulatory bodies in testing automotive equipment for approval within their respective State jurisdictions. Consequently, a subcommittee was appointed under the Research Committee to study the new problem in cooperation with the Automobile Lighting Committee of the Illuminating Engineering Society. A comprehensive experimental program was developed that included several sets of special head-lamp apparatus which were distributed among a number of automobile companies for use in making field tests. Subsequently, new specifications that had been studied by the Lighting Division were submitted with a view to their adoption as standard. The matter of voltage and candlepower has been an important factor in this study and it is thought by the Division that, to best meet the existing emergency situation in the various States, the specification proposed at this time should be limited to the depressed-beam type of lighting for 21-21-cp. lamps, especially as the present specifications for illumination as well as for the rating of electric incandescent lamps relate to the 21-cp. lamps.

To avoid confusion with the present S.A.E. Recommended Practice for Head-lamp Illumination for Motor-Vehicle Head-lamps, beginning on p. 42 of the September, 1927, issue of the S.A.E. HANDBOOK, the latter has been revised and incorporated in the proposed new specification, which provides for both the single-beam and the depressed dual-beam types of lighting.

It is also recommended by the Division that Part 2 of the present specification, Laboratory Tests for Desirable Illumination, commencing on p. 45 of the S.A.E. HANDBOOK, be discontinued, as it is not consistent with the proposed new specification.

The Division recommends approval of the following specifications:

SPECIFICATIONS FOR LABORATORY TESTS OF OPTICAL CHARACTERISTICS OF ELECTRIC HEAD-LAMPS FOR MOTOR-VEHICLES

S.A.E. Recommended Practice

Definitions

The term "head-lamp" as used in these specifications is intended to apply to any device including a light source and reflector, which is used on the front of a vehicle primarily to provide general illumination ahead of the vehicle. Spotlights and similar specialized lighting devices are not classified as head-lamps unless they are used or intended to be used to perform the ordinary functions of head-lamps as defined above.

The term "dual-beam equipment" as used herein is intended to apply to any device which permits the driver of the vehicle to use either of two distributions of light on the road.

Samples for Test

Sample head-lamps representative of the type as regularly manufactured and marketed shall be submitted to the laboratory for test. Such samples shall include all accessory equipment peculiar to the device and necessary to operate it in its normal manner, except that the socket sleeve may be omitted from the reflector. The samples shall be accompanied by printed, typewritten, or written instructions for adjustment, which will enable the laboratory operator to determine when the light source is located in the position it is designed to have, and to make any other adjustments necessary to obtain proper results from the lamps.

Incandescent Lamps

The incandescent lamps used in the tests, unless otherwise specified, shall be supplied by the laboratory. They shall be of standard manufacture of either 21 or 32 cp.[1] as specified by the applicant. They shall be of a construction approved for this purpose by the Bureau of Standards. The lamps shall be such as will give their rated candlepower when operated approximately at their rated efficiency. The results of photometric tests shall be based on the operation of the lamps at rated candlepower while the tests are being made.

Set-up for Testing

The laboratory shall be provided with facilities for making accurate measurements in accordance with established laboratory practices. The head-lamps shall be tested singly or in pairs as used and under conditions of installation similar to those in general use on motor vehicles. A photometer shall be set up not less than 60 nor more than 100 ft. from the head-lamps. When lamps are tested in pairs, the vertical planes through the axes of the lamps shall be parallel. If a testing distance of 100 ft. is taken, the lamps shall be 28 in. apart from center to center; if a shorter testing distance is taken, the distance between head-lamps shall be proportionately reduced.

Photometric Test Points

To assist in locating the test points, the following nomenclature has been adopted: The line formed by the intersection of the median vertical plane parallel to the lamp axes and the test screen shall be designated as *V*. The line formed by the intersection of the horizontal plane through the head-lamp centers and the test screen shall be designated as *H*. The point at the intersection of these two lines shall be designated as *H-V*. The other points on the screen shall be designated by similar symbols to indicate the number of degrees of arc above or below *H* and the number of degrees of arc to the left or right of *V*; for example, 4*D*-3*L* is a point 4 deg. below *H* and 3 deg. to the left of *V*, and 1*U*-*V* is a point 1 deg. above *H* in the median vertical plane.

The intensity of the combined light from the pair of sample head-lamps shall be measured. If the beam is symmetrical about the median vertical plane, measurements shall be made at 1-deg. intervals over an area extending from the center, *V*, to a line 12 deg. to the left (12*L*) and from a line 2 deg. above the head-lamp level (2*U*) to a line 6 deg. below the head-lamp level (6*D*). If the beam is not symmetrical about the median vertical plane, measurements shall also be taken in a similar manner to the right of the median vertical plane.

Focal Adjustment of Incandescent Lamps

Head-lamps shall be adjusted for the "normal" or design position of the light source in accordance with

[1] The laws or regulations of certain States establish candlepower limits for the lamps (bulbs) to be used. Tests made in connection with approval in such States should be made with lamps of the candlepower specified.

the instructions of the applicant. Complete distribution tests shall be made with the filament of the incandescent lamp in each of five positions, as follows: (*a*) design position, (*b*) 0.06 in. above design position, (*c*) 0.06 in. below design position, (*d*) 0.06 in. ahead of design position, and (*e*) 0.06 in. behind design position.

For dual-beam head-lamps, distribution tests shall be made on both the upper and the lower beam with the light source in each of the specified positions.

Aiming Adjustment of Head-Lamps

Each pair of head-lamps shall be aimed once for each position of the light source. Aiming adjustments for dual-beam head-lamps shall be made for upper beams only. The aiming of the upper beam shall be as high as is consistent with having both upper and lower beams comply with the limitations prescribed.

Beam Candlepower Requirements

While complete distribution tests are to be made for all filament positions, (*a*), (*b*), (*c*), (*d*), and (*e*), as specified under *Focal Adjustments of Incandescent Lamps*, compliance with the specifications shall be determined by candlepower limits at certain points or on certain lines.

(1) Dual-beam head-lamps designed for 21-21-cp. incandescent lamps.[2]

The values which follow are predicated on the assumption that in service no loading allowance will be made in the aiming of the upper beam. The upper beam shall comply with the following limitations:

	Candlepower Requirements	
	For Filament at Design Position	For Out-of-Design Filament Positions Specified
Point 1*U*-*V*	400 to 2,400	400 to 2,400
Point 1*U*-4*L*	800 or less	800 or less
Point *H*-*V*	1,800 to 6,000	1,800 to 6,000
Line 1*D*-3*L* to 3*R*	7,500 or more	6,000 or more
Line 2*D*-6*L* to 6*R*	4,000 or more	3,200 or more
Line 3*D*-9*L* to 9*R*	2,000 or more	1,600 or more
Maximum permissible beam candlepower (any point)	50,000	50,000
Point of maximum beam candlepower not lower than	2*D*	2½*D*

The lower beam shall comply with the following limitations:

	Candlepower Requirements	
	For Filament at Design Position	For Out-of-Design Filament Positions Specified
Line 1*U* from *V* to left	800 or less	800 or less
Line *H* from *V* to left	1,500 or less	1,500 or less
Line 1*D* from *V* to left	2,400 or less	2,400 or less
Point 2*D*-*V*	6,000 or less	6,000 or less
Point 3*D*-*V*	5,000 or more	4,000 or more
Line 4*D* or 5*D* or 6*D*, 12*L* to 12*R* (only one required)	1,000 or more	1,000 or more
Maximum permissible beam candlepower (any point)	25,000	30,000

[2] In States where 32-21-cp. lamps are permitted, the beam candlepower requirements may also be applied for equipments tested with these sources.

[3] In States where 32-cp. lamps are permitted, these beam candlepower requirements may be applied for equipments tested with such sources.

It is desirable that all classes of head-lamp shall meet the candlepower requirements for all five filament positions, but compliance is mandatory for the several classes of equipment as follows:

(*A*) Head-lamps equipped with no focus-adjusting mechanism:
Filament position: (*a*) design position, (*b*) 0.06 in. above design position, (*c*) 0.06 in. below design position, (*d*) 0.06 in. ahead of design position, and (*e*) 0.06 in. behind design position

(*B*) Head-lamps equipped with a horizontal focus-adjusting mechanism, whether or not they are also equipped with a vertical-focus adjusting mechanism:
Filament position: (*a*) design position, (*b*) 0.06 in. above design position and (*c*) 0.06 in. below design position

(*C*) Head-lamps equipped with a vertical focus-adjusting mechanism only:
Filament position: (*a*) design position, (*b*) 0.06 in. above design position, (*c*) 0.06 in. below design position, (*d*) 0.06 in. ahead of design position, (*e*) 0.06 in. behind design position, and (*f*) at the limits of vertical motion if such limits exceed 0.06 in.

(2) Fixed-beam head-lamps designed for 21-cp. incandescent lamps.[3]

The values which follow are predicated on the assumption that, in the aiming of the beam, allowance will be made for the loading of the car.

The beam shall comply with the following limitations:

	Candlepower Requirements	
	For Filament at Design Position	For Out-of-Design Filament Positions Specified
Point 1*U*-*V*	400 to 2,400	400 to 2,400
Point 1*U*-4*L*	800 or less	800 or less
Point *H*-*V*	1,800 to 6,000	1,800 to 6,000
Line 1*D*-3*L* to 3*R*	7,500 or more	6,000 or more
Line 2*D*-6*L* to 6*R*	4,000 or more	3,200 or more
Line 3*D*-9*L* to 9*R*	2,000 or more	1,600 or more
Maximum permissible beam candlepower (any point)	50,000	50,000
Point of maximum beam candlepower not lower than	2*D*	2½*D*

It is desirable that all classes of head-lamp shall meet the candlepower requirements for all five filament positions, but compliance is mandatory for the several classes of equipment as follows:

(*A*) Head-lamps equipped with no focus-adjusting mechanisms:
Filament position: (*a*) design position, (*b*) 0.06 in. above design position, (*c*) 0.06 in. below design position, (*d*) 0.06 in. ahead of design position, and (*e*) 0.06 in. behind design position

(*B*) Head-lamps equipped with a horizontal focus-adjusting mechanism, whether or not they are also equipped with a vertical focus-adjusting mechanism:
Filament position: (*a*) design position, (*b*) 0.06 in. above design position, and (*c*) 0.06 in. below design position

(*C*) Head-lamps equipped with a vertical focus-adjusting mechanism only:
Filament position: (*a*) design position, (*b*) 0.06 in. above design position, (*c*) 0.06 in. below design position, (*d*) 0.06

in. ahead of design position, (e) 0.06 in. behind design position, and (f) at the limits of vertical motion if such limits exceed 0.06 in.

Reports

The report shall include the manufacturer's instructions for locating the design position of the light source.

(*General Information*)

To assure test results which represent average performance and to minimize variations in test data between laboratories, careful attention shall be given by the testing laboratory to the selection of test lamps of standard manufacture to be supplied by the laboratory as specified in the section on *Incandescent Lamps*. Such lamps shall be of the focusing type described under the heading Electric Incandescent Lamps in the Electrical Equipment Section of the S.A.E. HANDBOOK. The filament coils shall be symmetrical, with approximately the same number of turns in each. The axes of the filament coils shall be straight and shall form a V with the base toward the base end of the lamp and with the legs at an angle of 30 deg. to each other. In 6-8-volt lamps the length along the lamp axis and the over-all width of the base of the filament shall both be 0.100 in. ± 0.005 in. Lamps shall be installed in test head-lamps so that the axis in the plane of the filament at 90 deg. to the axis of the bulb is horizontal. In single-filament lamps the geometric center of the filament shall be at the center of the spherical part of the bulb. In double-filament lamps the geometric centers of the filament shall be 0.070 in. ± 0.002 in. above and below the center of the bulb. In double-filament bulbs one filament shall not be more than 0.005 in. behind the other.

MOTORCOACH DIVISION

PERSONNEL

A. J. Scaife, *Chairman*	White Motor Co.
S. W. Mills, *Vice-Chairman*	Pierce-Arrow Motor Car Co.
Nels G. Anderson	International Harvester Co.
B. V. Evans	Detroit
F. P. Freeman	South Orange, N. J.
W. F. Klein	General Motors Truck Co.
W. T. Lutey	Lang Body Co.
W. E. Martin	United Railways & Electric Co.
L. H. Palmer	Fifth Avenue Coach Co.
G. H. Scragg	International Motor Co.
P. V. C. See	Northern Ohio Traction & Light Co.
E. W. Templin	Philadelphia
F. A. Whitten	American Car & Foundry Motors Co.

VACUUM-BRAKE MANIFOLD CONNECTION

Motorcoach Division Approves 3/8-In. Tapped Hole in Manifold as Standard

The development of specifications for power-brake-compressor mountings and connections and vacuum-brake connections has been under consideration by a subdivision of the Motorcoach Division for some time.

The types of compressor now on the market vary so greatly in method of driving and mounting that no standard mounting specifications can be formulated.

However, it was thought advisable to set a standard tapped-hole size in manifolds to permit the attachment of vacuum-brake equipment. The cost to engine manufacturers of providing such a hole at the time the engine is built is relatively small and, while the specifications are drawn up as a vacuum-brake-connection specification, it is anticipated that the providing of such a hole in the manifold will be of value as a connection for other vacuum attachments if desired.

The Division recommends the approval of the following specification:

VACUUM-BRAKE MANIFOLD CONNECTIONS

(*S. A. E. Recommended Practice*)

The vacuum-brake manifold connection shall be a 3/8-in. hole tapped with the American Standard pipe-thread.

PARTS AND FITTINGS DIVISION

PERSONNEL

H. S. Jandus, *Chairman*	C. G. Spring & Bumper Co.
A. Boor, *Vice-Chairman*	Willys-Overland Co.
Joseph Berge	Crowner Co.
A. K. Brumbaugh	White Motor Co.
R. V. Hutchinson	Olds Motor Works
W. C. Keys	United States Rubber Co.
G. L. McCain	Dodge Bros., Inc.
Ivan Ornberg	Hupp Motor Car Corporation
W. J. Outcalt	General Motors Corporation
C. W. Spicer	Spicer Mfg. Corporation
F. C. Stanley	Raybestos Co.
F. G. Whittington	Stewart Warner Speedometer Corporation
H. T. Woolson	Chrysler Corporation

PASSENGER-CAR BUMPER MOUNTINGS

Clamp Bolt-Hole Spacings Are Added for Integral Frame-Horn Mountings

In view of the considerably increasing use of integral frame-horn types of bumper mountings it is considered advisable to provide bumper mounting-bar widths in the present specifications on bumper mountings, p. 208 of the September, 1927, issue of the S.A.E. HANDBOOK, so that designers may adopt proper bolt-hole spacings in the mounting clamp.

After considerable study by a Subdivision of the Parts and Fittings Division, it was found inadvisable to attempt to specify any dimensions other than the mounting-bar widths, and the Division therefore recommends insertion of the following paragraph in the present S.A.E. Recommended Practice on Front Bumper Mountings.

In cases where integral frame-horn mountings are desired, the clamp bolt-hole spacings should be such as to anticipate a standard bumper-mounting-bar width, the sizes of which are as follows: 1½, 1¾, 2, 2¼, 2½ in.

WOODRUFF KEY SPECIFICATIONS

Dimensions and Tolerances on Keys, Key Seats, and Key above Shaft Developed

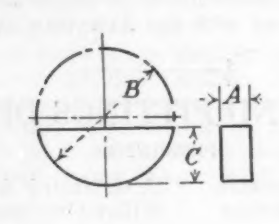
Owing to the difficulty experienced in assembling Woodruff keys in shafts and their retainment during the handling of shafts in process of assembly in various types of equipment, it is thought advisable to develop dimensions and tolerances for keys and key seats so that keys will be retained in the shaft during assembly and yet not fit so tightly as to result in shaft distortion.

D. W. Ovaitt, as a member of the Parts and Fittings Division and as Chairman of the Tap and Gage Committee of the General Motors Corporation, undertook this work and after several months of research presented the following specifications to the Division for consideration.

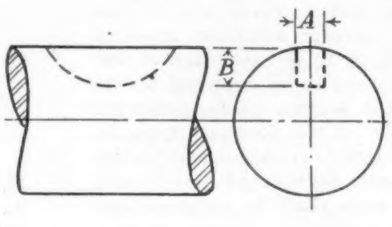
The work done to date also includes diameters and widths of cutters, with their tolerances, and gages for key seats, but these two items are to be brought up for consideration later by the Production Division and are not a part of this report.

These specifications are based upon present practice with reference to the manufacture and use of Woodruff keys in the automotive industry, which consumes about 90 per cent of this type of key produced. The following tables are recommended to the Standards Committee by the Parts and Fittings Division for approval as an S.A.E. Standard.

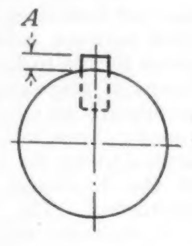
PROPOSED WOODRUFF KEY STANDARDS



KEY



KEYSEAT



KEY ABOVE SHAFT

Size	KEY Width (A)		KEY Diameter (B)		KEY Height (C)		KEYSEAT Width (A)			KEYSEAT Depth (B)		KEY ABOVE SHAFT Height (A)		
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Basic	Minimum	Maximum	Minimum	Maximum	Basic	Minimum	Maximum
10	0.0625	0.0635	0.490	0.500	0.198	0.203	0.0625	0.0615	0.0630	0.1668	0.1718	0.0312	0.0262	0.0362
20	0.0938	0.0948	0.490	0.500	0.198	0.203	0.0938	0.0928	0.0943	0.1511	0.1561	0.0469	0.0419	0.0519
30	0.1250	0.1260	0.490	0.500	0.198	0.203	0.1250	0.1240	0.1255	0.1355	0.1405	0.0625	0.0575	0.0675
40	0.0938	0.0948	0.615	0.625	0.245	0.250	0.0938	0.0928	0.0943	0.1981	0.2031	0.0469	0.0419	0.0519
50	0.1250	0.1260	0.615	0.625	0.245	0.250	0.1250	0.1240	0.1255	0.1825	0.1875	0.0625	0.0575	0.0675
60	0.1563	0.1573	0.615	0.625	0.245	0.250	0.1563	0.1553	0.1568	0.1669	0.1719	0.0781	0.0731	0.0831
70	0.1250	0.1260	0.740	0.750	0.308	0.313	0.1250	0.1240	0.1255	0.2455	0.2505	0.0625	0.0575	0.0675
80	0.1563	0.1573	0.740	0.750	0.308	0.313	0.1563	0.1553	0.1568	0.2299	0.2349	0.0781	0.0731	0.0831
90	0.1875	0.1885	0.740	0.750	0.308	0.313	0.1875	0.1863	0.1880	0.2143	0.2193	0.0937	0.0887	0.0987
100	0.1563	0.1573	0.865	0.875	0.370	0.375	0.1563	0.1553	0.1568	0.2919	0.2969	0.0781	0.0731	0.0831
110	0.1875	0.1885	0.865	0.875	0.370	0.375	0.1875	0.1863	0.1880	0.2763	0.2813	0.0937	0.0887	0.0987
115	0.2500	0.2510	0.865	0.875	0.370	0.375	0.2500	0.2487	0.2505	0.2450	0.2500	0.1250	0.1200	0.1300
130	0.1875	0.1885	0.990	1.000	0.433	0.438	0.1875	0.1863	0.1880	0.3393	0.3443	0.0937	0.0887	0.0987
150	0.2500	0.2510	0.990	1.000	0.433	0.438	0.2500	0.2487	0.2505	0.3080	0.3130	0.1250	0.1200	0.1300
155	0.3125	0.3135	0.990	1.000	0.433	0.438	0.3125	0.3111	0.3130	0.2768	0.2818	0.1562	0.1512	0.1612
160	0.1875	0.1885	1.115	1.125	0.479	0.484	0.1875	0.1863	0.1880	0.3853	0.3903	0.0937	0.0887	0.0987
180	0.2500	0.2510	1.115	1.125	0.479	0.484	0.2500	0.2487	0.2505	0.3540	0.3590	0.1250	0.1200	0.1300
185	0.3125	0.3135	1.115	1.125	0.479	0.484	0.3125	0.3111	0.3130	0.3228	0.3278	0.1562	0.1512	0.1612
210	0.2500	0.2510	1.240	1.250	0.542	0.547	0.2500	0.2487	0.2505	0.4170	0.4220	0.1250	0.1200	0.1300
215	0.3125	0.3135	1.240	1.250	0.542	0.547	0.3125	0.3111	0.3130	0.3858	0.3908	0.1562	0.1512	0.1612
225	0.3750	0.3760	1.240	1.250	0.542	0.547	0.3750	0.3735	0.3755	0.3545	0.3595	0.1875	0.1825	0.1925
230	0.3125	0.3135	1.365	1.375	0.589	0.594	0.3125	0.3111	0.3130	0.4328	0.4378	0.1562	0.1512	0.1612
235	0.3750	0.3760	1.365	1.375	0.589	0.594	0.3750	0.3735	0.3755	0.4015	0.4065	0.1875	0.1825	0.1925
240	0.2500	0.2510	1.490	1.500	0.636	0.641	0.2500	0.2487	0.2505	0.5110	0.5160	0.1250	0.1200	0.1300
250	0. 125	0.3135	1.490	1.500	0.636	0.641	0.3125	0.3111	0.3130	0.4798	0.4848	0.1562	0.1512	0.1612
255	0.3750	0.3760	1.490	1.500	0.636	0.641	0.3750	0.3735	0.3755	0.4485	0.4535	0.1875	0.1825	0.1925

Width.—Dimensions shown are set with the minimum key width as basic.
Tolerance on all key widths to be .001.
Maximum key width is basic plus tolerance.
Diameter.—Dimensions shown are set with maximum diameter as basic. (From American Society of Mechanical Engineers proof sheet dated October, 1926).
Tolerance on all key diameters to be 0.010.
Minimum key diameter is basic minus tolerance.
Height.—Dimensions shown are set with maximum height as basic. (From American Society of Mechanical Engineers proof sheet dated October, 1926).
Tolerance on all key heights to be 0.005.
Minimum key height is basic minus tolerance.

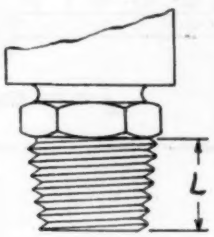
Width.—Dimensions shown are set with the maximum keyslot width as that figure which will receive a key with the greatest amount of looseness permissible to assure the key sticking in the slot.
Minimum keyslot width is that figure permitting the largest shaft distortion acceptable when assembling maximum key in minimum keyslot.
The largest shaft distortion acceptable in all calculations was 0.0003 not more than 3/16 in. from side of assembled key.
Depth.—Dimensions shown are set with the maximum as that figure which receives a key of maximum height and permits the key to project above the shaft a distance equal to one half the basic width.
Tolerance on all keyslot depths 0.005.
Minimum keyslot depth is maximum minus tolerance.

Height. — Dimensions shown are set with one half the basic key as basic height.
Tolerance on key height above shaft plus or minus 0.005.

OIL AND GREASE-CUP THREADS

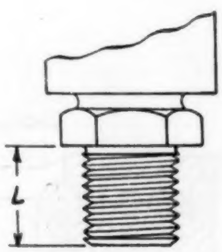
Revised Specifications Include Thread Length and Width across Shank Flats

As the present Oil and Grease-Cup Thread Specifications, p. 212 of the September, 1927, issue of the S.A.E. HANDBOOK, cover only size and type of thread of the shank, it was thought advisable to expand these specifications to include a minimum length of thread and the width across the flats of the hexagon shank. Dimensions of the latter have been chosen in accordance with the nearest reasonable hexagon used on S.A.E. Bolts and Nuts, and should be universally acceptable in the automotive industry. While some manufacturers use larger hexagon sizes because they have been carried over from old and larger fittings, it is believed that a standardization of S.A.E. Hexagon Sizes will be agreeable to the automotive industry. The following tables of dimensions were developed by a Subdivision of the Parts and Fittings Division and are presented herewith to the Standards Committee for approval as a revision of the present specifications:



American Standard Pipe Thread[1] Size	Threads per In.	Width across Flats of Hexagon	*L* Minimum Length
1/8	27	7/16	3/8
1/4	18	9/16	7/16
3/8	18	3/4	1/2
1/2	14	7/8	5/8

[1]Threads to fit American standard pipe-thread gages.



Thread Diameter	Threads Per In.	Width across Flats of Hexagon	*L* Minimum Length
No. 10	32	3/8	1/8
1/4	32	7/16	3/16
5/16	32	7/16	1/4

TAPER-FITTING TOLERANCES REVISED

Division Recommends Closer Limits for S.A.E. Tapers To Assure Accuracy of Fit

A survey of manufacturers employing the S.A.E. Taper Fitting in their products indicated the need for a revision of the present tolerances to provide greater accuracy of fit.

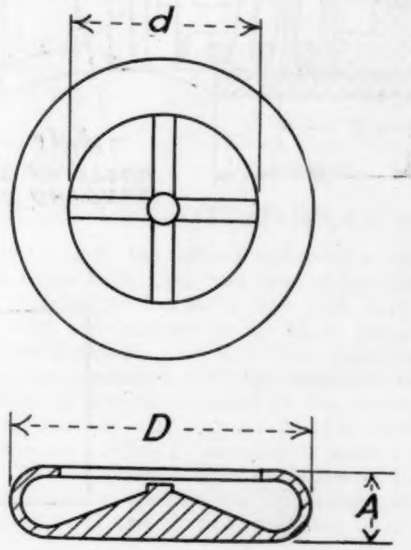
After consideration of the results of this survey, the Division recommends that the Standards Committee approve a change in the tolerances on the taper per foot from plus or minus 0.005 in., to plus or minus 0.002 in. where tolerances are shown in the taper-fitting specifications on p. 187 of the September, 1927, issue of the S.A.E. HANDBOOK.

RIVET CAP SPECIFICATIONS

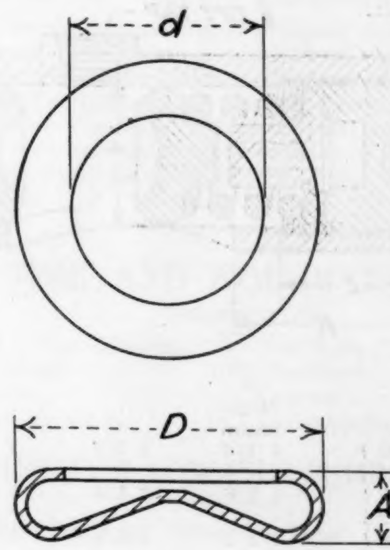
Three Sizes for Split and Tubular Rivets Recommended by Subdivision

Since the formulation of the present Specifications on Split and Tubular Rivets, a need has been found for standard dimensional specifications on rivet caps to be used with these types of rivet.

The use of this item was found to be confined to three sizes and two types, and the Division recommends the approval of the following specifications as part of the Recommended Practice on Split and Tubular Rivets:



A	*D*	*d*
5/64	23/64	7/32



A	*D*	*d*
5/64	21/64	7/32
7/64	27/64	17/64

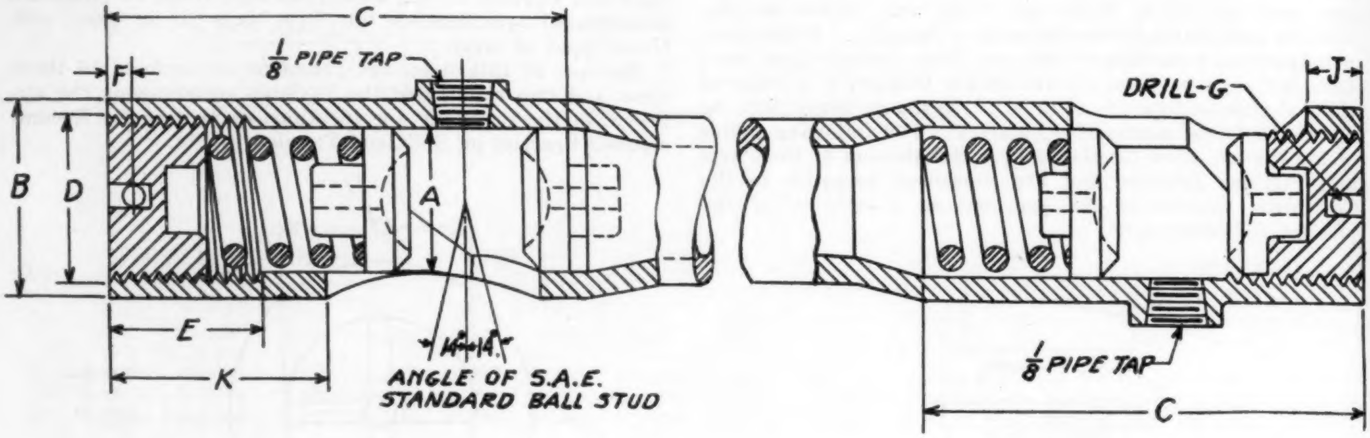
STEERING-GEAR CONNECTING-RODS

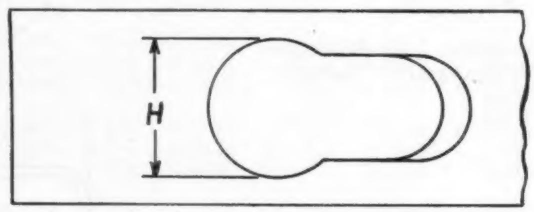
New Basic Dimensional Specifications on Socket, Plug, Ball Seat and Spring

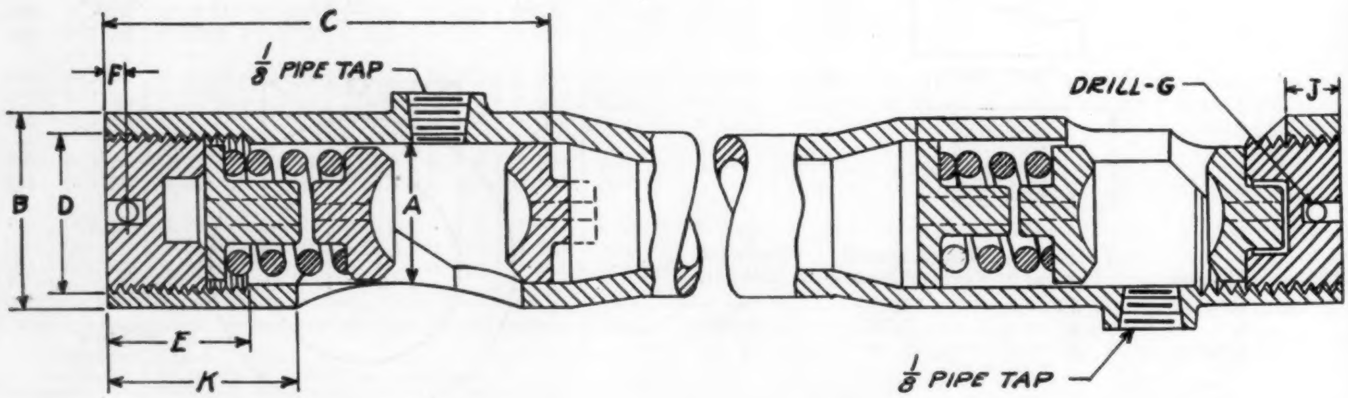
The following specifications, developed by a Subdivision of the Parts and Fittings Division, were formulated after a study of the dimensions now generally adhered to by manufacturers and users of this product. It was decided at the time the specifications were drawn up that, because of the varying tube requirements demanded by bent steering-gear connecting-rods, no attempt should be made to include anything with reference to the wall thickness or diameter of tubing to be used for ball studs of various sizes and to omit all mention of the tubing with the exception of the note on the quality of the steel recommended.

The design showing the use of the spacer is included for information only; no specifications were worked out on the spacer itself owing to differences of opinion as to its value and to lack of any standard practice in its use.

The Division recommends the following specifications for approval as an S.A.E. Recommended Practice:



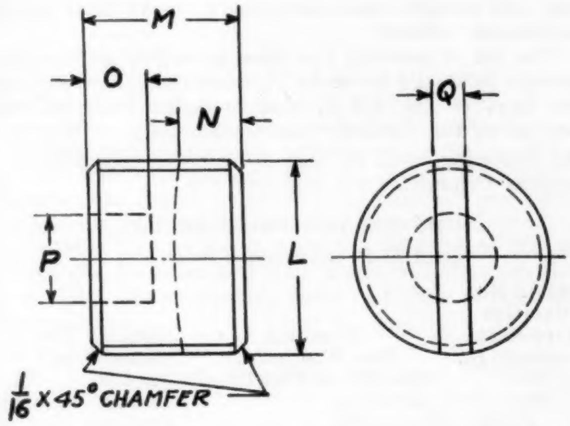




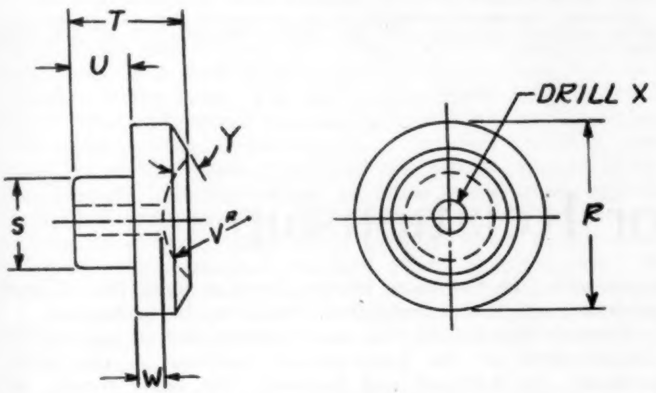
Nominal Ball Size	A	B Minimum	C	D	E	F	G	H	J	K
1	1.005 / 1.015	1 1/4	2 7/8	1 1/16 x 20	3/4	3/16	5/32	1.015	1/2	1 1/4
1 1/8	1.127 / 1.132	1 3/8	3 1/4	1 3/16 x 16	7/8	3/16	5/32	1.140	9/16	1 1/2
1 1/4	1.250 / 1.255	1 1/2	3 3/4	1 5/16 x 18	1 3/16	3/16	5/32	1.265	1	1 15/16
1 1/2	1.505 / 1.515	1 7/8	4 3/8	1 19/32 x 14	1 1/4	5/16	7/32	1.515	1	2
1 3/4	1.760 / 1.790	2 1/8	5	1 7/8 x 12	1 3/8	5/16	7/32	1.765	1 1/8	2 1/8

Tubing Stock

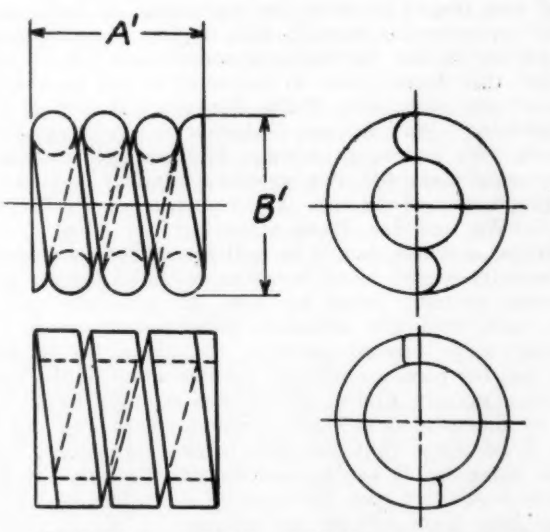
Tubing to be cold-drawn seamless steel not inferior to S.A.E. 1020



Nominal Ball Size	L	M + 1/64 —0	N Minimum	O + 1/64 —0	P Minimum	Q Minimum
1	1 1/16 x 20	21/32	23/64	13/64	7/16	5/32
1 1/8	1 3/16 x 16	3/4	3/8	17/64	13/32	5/32
1 1/4	1 5/16 x 18	1 1/16	13/32	13/32	5/8	5/32
1 1/2	1 19/32 x 14	1 1/8	1/2	15/32	57/64	1/4
1 3/4	1 7/8 x 12	1 1/4	1/2	17/32	1 1/32	1/4



Nominal Ball Diameter	R —0.010 +0	S Maximum	T +0 —1/64	U +0 —1/64	V +0.005 —1/64	W +0 —0.005	X	Y
1	0.995	0.427	33/64	3/16	1/2	0.187	9/64	45°
1 1/8	1.115	0.557	37/64	1/4	9/16	0.187	3/16	45°
1 1/4	1.234	0.591	23/32	3/8	5/8	0.187	3/16	30°
1 1/2	1.478	0.843	15/16	7/16	3/4	0.312	1/4	45°
1 3/4	1.750	0.984	1 1/8	1/2	7/8	0.375	1/4	30°



SQUARE WIRE SPRING OPTIONAL

Nominal Ball Size	Approximate Free Length A′	Outside Diameter B′	Working Load, Lb.
1	7/8	31/32	275=25
1 1/8	1 1/16	1 3/32	375=50
1 1/4	1	1 3/16	450=50
1 1/2	1 5/32	1 15/32	400=50
1 3/4	1 1/4	1 11/16	580=50

SCREW-THREADS DIVISION

PERSONNEL

E. H. Ehrman, *Chairman*	Standard Screw Co.
G. S. Case, *Vice-Chairman*	Lamson & Sessions Co.
A. Boor	Willys-Overland Co.
E. J. Bryant	Greenfield Tap & Die Corporation
Earle Buckingham	Massachusetts Institute of Technology
Ellwood Burdsall	Russell, Burdsall & Ward Bolt & Nut Co.
L. D. Burlingame	Brown & Sharpe Mfg. Co.
R. M. Heames	Victor Peninsular Co.
K. L. Herrmann	Studebaker Corporation of America
D. W. Ovaitt	Buick Motor Co.
O. B. Zimmerman	International Harvester Co.

ROUND UNSLOTTED-HEAD BOLTS

In January, 1927, the Society approved a report on Round Unslotted-Head Bolts that had been submitted to it by the Sectional Committee on Bolt, Nut and Rivet Proportions and that had been printed on p. 27 of the January, 1927, issue of The Journal. At that time, however, the Society, as one of the sponsors for the Sectional Committee, requested that a note be included in the report stating that the tables of body and thread lengths therein were intended more as a guide to practice than as a definite specification. The Sectional Committee's report has accordingly been rearranged to include the following note referring to the tables of body and thread lengths:

> *Note:* The table of body and thread lengths reproduced above is intended as a guide to the users of these bolts. Many of the listed sizes and lengths will not be regularly stocked by the manufacturers but will be available on order of a sufficient quantity.

At the time of preparing this report for publication in this issue of The Journal, the text of the proposed note was before the Screw-Threads Division of the Standards Committee for approval, as the subject was originally assigned to this Committee by the Council, but as the ballot had not been completed, final submission of the report to the Standards Committee is dependent on the result of the Division ballot.

TIRE AND RIM DIVISION

PERSONNEL

H. M. Crane, *Chairman*	New York City
R. S. Begg,	Cleveland
C. Breer,	Detroit
T. J. Litle, Jr.	Indianapolis

RIMS FOR LOW-PRESSURE TIRES

Simplified Table of Sizes To Meet Present Requirements Drafted by Division

The following report of Chairman Crane, of the Tire and Rim Division, is explanatory of the basis of the revision of the present S.A.E. Recommended Practice on Rims

for Low-Pressure Tires, p. 437 of the September, 1927, issue of the S.A.E. HANDBOOK. If approved and printed in the S.A.E. HANDBOOK, the revised table will be prefaced by an introductory paragraph based on the information contained in this statement:

The revision of the S.A.E. Recommended Practice on Rims for Low-Pressure Tires proposed by the Tire and Rim Division of the Standards Committee is believed by the members to represent a very definite advance toward a most desirable simplification in the number of sizes. The action of the Division was based entirely on experience and with the object of eliminating all inconsistent and unnecessary sizes.

The retention of the 21x2.75 rim may seem to be out of line, but this represents a voluntary standardization by Ford and Chevrolet and covers too large a production to be ignored. The 21-in. wheel diameter undoubtedly reflects the large use of these low-cost cars in rough country. It is believed that ultimately, however, a 20-in., or smaller, wheel will probably come into use. The width of this rim is also out of line with other rims. There is still a wide variety of opinion in the tire industry as to the optimum rim width for a given cross-section. This is one of the features of tire design on which definite engineering knowledge is still lacking. As the variation in the life of individual tires is greater than that produced by any ordinary change in rim width, the formulation of a conclusive set of tests appears to be difficult, if not impossible. Undoubtedly the inflation pressure used would have to be taken into account.

In any case, the use of this rim is apt, if successful, to tend to increase the widths used with larger cross-sections. We have advanced greatly in our knowledge of factors affecting tire design, but there are still enough open questions to make final standardization difficult.

The list of nominal tire sizes is largely self-explanatory. It should be borne in mind that these are not yet part of the S.A.E. Recommended Practice, but are given for General Information only.

The following table of sizes is herewith submitted to the Standards Committee for approval:

RIMS FOR LOW-PRESSURE TIRES

(*S.A.E. Recommended Practice*)

Nominal Rim Diameter (Tire-Seat Diameter), In.	Nominal Rim Width, In.	Nominal Tire Sizes Used[1]
21	2.75 DC or Flat Base[2]	30x4.50
18	4	28x5.25, 30x6.00[a]
19	4	29x5.00[a], 29x5.50[a], 31x6.00[a]
19	4½	31x6.00[a]
20	4½	32x6.00[a]
20	5	32x6.00[a], 32x6.75[a]

[1] Tire sizes are not a part of this specification, but are given to show the nominal tire sizes used on each rim.

[2] Decimal dimension refers to width between flanges. On other rims the dimension given is nominal width including flanges.

[a] These tire sizes conform to the recommended standard tire cross-sections approved by the Rubber Association of America, April 22, 1927.

Capital and Labor Relationship

THE new relationship between capital and labor in Europe shows itself in the solicitude of the employer for the welfare of his employe and in the heartiness with which the worker is cooperating with the cost-reduction efforts of industry. This solicitude springs, not primarily from humanitarian motives, but from the realization that Europe's lack of prosperity springs from the insufficient purchasing power of her people and of those in other lands. It has dawned on the manufacturer that well-paid workers are good customers and that good customers keep factories busy. Of course, the manufacturer is not rushing at once to raise wages, but his former resistance to wage increases is tempered by the conviction that his prosperity is tied up with that of his workers. Further, the cost-reduction drive works hand in glove with the new labor attitude, for the means to raise wages will come from the savings effected through the cost-reduction drive.

Here the worker enters the picture. He, too, realizes that Germany's "come-back" and his own prosperity depend upon economy of production. He has learned some of the fundamentals of industrial economics. Accordingly, the officers of the German federation of labor unions are urging their members to cooperate with the employers in cost-reduction efforts, demanding, though, that they shall not be exploited in the process but shall share in the resulting savings.

How strikingly this attitude contrasts with that of the worker in America at the beginning of the "scientific management" movement 20 years ago! Then the idea was not explained to the worker. He was not consulted, much less asked to help. He suspected a new scheme for getting more work for the same or less pay, even though the efficiency engineers were first to enunciate the doctrine that high wages could accompany low production costs. But the worker had not been made a party to the new movement. In Germany he has been brought into it and made a part of it. Instead of impeding, he is helping.

Another element in this new relationship is an evident abandonment of the paternalistic solution of the labor problem. In England and Germany the labor theory, at least as it displayed itself in practice, was that of the bare living wage, leaving the care for sickness, unemployment and old age to State insurance funds. To these funds, the State, the employer and the employe all contributed. Despite these insurance plans, the worker was not contented, and in Germany socialism increased rapidly before the war.

The new theory is more like our own. It looks on the worker as a good customer, and implies something more than ability to buy the mere necessaries of life. I would say that this development in Germany is but another evidence of the soundness of the American theory of labor relationship. We do not believe in State insurance schemes. We believe in a wage high enough so that the worker may make his own provision against sickness and unemployment and old age. I call such a wage a "security wage." We are far from achieving our ideal for the Country as a whole, but if we will set up for our objective the "security wage" in all industry, we shall build a sound industrial system, based on men of initiative, men of thrift, men who are satisfied, ambitious workers. The "security wage" would provide, not alone for a decent living, but for home ownership, the education of the family and for a margin giving the worker security against the fears of unprovided sickness, unemployment and old age.

Let it be noted that the new labor relationship makes for the same result as the cost-reduction effort. It helps to lower production cost, for reasons so evident that I need not go into them.—From an address by E. J. Mehren, at the New York Building Congress.

News of Section Meetings

(*Continued from p. 14*)

Opinions of the chemists and chemical engineers regarding what the large oil companies will do when the supply of petroleum now obtained from wells is exhausted to such an extent that it becomes necessary to find a substitute fuel was the topic presented by Professor McAdams. The date when the supply of crude petroleum becomes exhausted is uncertain, he said, but this time surely will come. As to sources that can be relied upon for substitutes for present motor fuels, he remarked that the possibilities are developing rapidly. Some possible fuels and their sources that he mentioned are:

(1) Shale oil
(2) Alcohols, which include methanol from wood, ethyl alcohol, patard methanol from coke and methanol from waste fermentation gases
(3) Fisher gasoline from coke
(4) Bergius gasoline from coal and similar substitutes

Commenting on the variations in antiknock values of motor fuels as affected by the crude petroleum used and the cracking process used, Professor McAdams remarked that straight-run gasoline made from Pennsylvania crude petroleum has a high knock-rating, that from Mid-Continent crude knocks less, that from California crude knocks still less, and that from crude petroleum from Java and Borneo is the best. The explanation given by chemists is that these differences are due to variations in the content of non-knocking hydrocarbons. The non-knocking compounds in the crude petroleum are mostly aromatics and naphthenes. Straight-chain paraffins cause knock and the branched-chain paraffins are non-knocking, but the presence of branched-chain paraffins in gasoline is not firmly established. He remarked further that, unfortunately, the chemists never have isolated from petroleum a single hydrocarbon which has a boiling-point higher than 300 deg. fahr., although 25 per cent of gasoline boils at a higher temperature.

Demonstration of Antiknock Gasoline

Supplementing the subject matter of Professor McAdams' paper, Dr. Calingaert emphasized that fuel should be rated in terms of doing the same kind of thing in an engine as does some certain standard fuel, so that there may be a constant standard of comparison. In his demonstration to illustrate the method of testing the antiknock qualities of gasoline, he used a one-cylinder four-cycle engine and the bouncing-pin-indicator method, and also showed lantern slides to illustrate the characteristics of various grades of motor fuels.

In making fuel-comparison tests, Dr. Calingaert said that the sooner one fuel is tested after the other fuel has been tested the better the results will be. The method used in the laboratory of the company he represents consists in running an engine for 1 min. on one fuel, measuring the amount of knock, then shifting as quickly as possible to the first fuel tested and repeating this process until fairly constant readings are obtained.

Major Points in the Discussion

Asked what percentage of dilution by fuel is permissible in crankcase oils, Mr. Round replied that 20 per cent is about the limit in the grades of oil normally used in winter. He said also that, of the two, water dilution and fuel dilution, that by water is the more serious. Dilution caused by water is evidenced by the formation of sludge and is thus relatively easy to identify, but there is no practicable method by which a car owner can determine the amount of dilution, this being a laboratory procedure. He stated that the chief advantage claimed for prediluted oil is that it facilitates starting from cold. A prediluted oil is a heavy-bodied oil containing a certain amount of diluent. The use of such an oil does give easier starting; but, unfortunately, if certain operating conditions drive off the diluent, the remaining oil is too heavy and will cause difficulty in starting.

Rather long discussion of the pros and cons of the methods of minimizing dilution, sulphur content in fuel and its effect in causing corrosion, and the most desirable schedule for crankcase drainage was participated in by numerous members.

Asked what the advantage is of using antiknock high-compression gasoline in an engine which is not a high-compression engine, Dr. Calingaert said that, even if the engine does not knock so that it can be heard, its action is dependent upon the way the hydrocarbon is burning. Realization of the knocking depends upon the ear and, while the engine may be knocking, it is not evident until it reaches the particular point at which what happens can be heard. But before the knock reaches the point at which it becomes audible, there are detrimental effects. Antiknock gasoline provides smoother operation than does ordinary gasoline.

DESIGN CHANGES AND MAINTENANCE

Pleas Made for Consideration of Service Organization to Pennsylvania Section

Some of the troubles of distributors' service departments caused by vehicle manufacturers' changes in design on current models were recounted by Carroll A. McShane, service manager for the Jordan Co. of Philadelphia, at the Dec. 20 meeting of the Pennsylvania Section. The difficult position in which the service departments throughout the Country are placed by failure of the manufacturer's organization to give sufficient advance notice of coming design changes and to arrange for adequate supplies of replacement parts and for shop equipment and tools to fit changed parts was recounted and the speaker made a plea for more forethought in this respect on the part of car makers.

Mr. McShane, in conclusion, suggested that the engineering force of every automobile factory bear in mind always that factory contact with the public and with the distributors who buy and sell the maker's product is maintained through the factory service manager and his department and that the service manager should be notified in advance of any change in design or construction so that his field organization will be in position to handle promptly any complaint arising from the change. The speaker also said he wished to impress upon all who are in any way connected with factory organizations that departures from the usual to the unusual are not welcomed by the public nor by any distributing organization unless the departure will more than justify the time and the expense involved in effecting the change on cars already shipped.

Another speaker of the evening was J. G. Moxey, of the Atlantic Refining Co., who took the place of J. F. Winchester, who was scheduled to speak but was unable to be present on account of illness. Mr. Moxey dealt with the trucking problem, emphasized the importance of closer co-operation between the manufacturer and the service department and stressed the desirability of more complete standardization of parts to facilitate interchangeability.

The two addresses were discussed by E. B. Neil, Mr.

McShane, Mr. Moxey, H. C. Gibson, J. E. Nidecker, R. E. Lomer, and Dalton Risley, Jr.

Fifty members and guests attended the meeting in the rooms of the Philadelphia Automobile Trade Association, which was preceded by a members' dinner and a musical entertainment. Norman G. Shidle opened the meeting and then relinquished the chair to Donald Blanchard, who had arranged the program. At the end of the session, Mr. Shidle announced that no meeting of the Section will be held in January, on account of the Annual Meeting of the Society.

X-RAYING ENGINEERING MATERIALS

Dr. Clark Discloses to the Chicago Section Recent Progress in Applications

New Advances in the Study of Engineering Materials by Means of X-Rays was the theme chosen by Dr. George L. Clark, of the University of Illinois, for his address at the monthly meeting of the Chicago Section, held in the rooms of the Western Society of Engineers in the Monadnock Block, Chicago, on Dec. 13. Dr. Clark, who until recently has carried on his researches at the Massachusetts Institute of Technology, has already described the nature of his work, at the last Annual Meeting of the Society and also at the Summer Meeting at French Lick Springs, Ind., but the applications of X-rays to the study of materials seem to be endless and many new developments have been made since he last appeared before the Society.

Before taking up the principal part of his discussion, Dr. Clark described the present status of his work with the spectroscope in the study of detonation in internal-combustion engines. In this study, the light produced in the cylinder by the combustion of gases is spread into its spectrum and analyzed, with a view to getting an adequate explanation of the probable cause of the mechanism of such agents as tetraethyl lead in preventing detonation. Inasmuch as the visible light rays emitted during an explosion are not a sensitive indication of the differences between smooth explosion and detonation, resort was had to the more sensitive light rays; that is, the ultraviolet region of the spectrum. Though yet far from complete, a serious program of research is contemplated in this field under carefully controlled conditions; and slides were shown of the progress made up to the present.

These included the results of experiments performed with a view to getting a fundamental basis of operation and from which it was found that the continuous spectrum of hydroxyl was present during the burning of all kinds of gasoline. Other bands, such as those of the various carbon compounds, were also investigated. A study of the ultraviolet spectra of the light emitted from the muzzles of guns when fired has led to the solution of the problem of preventing the flashes by a proper admixture with the powder of a substance that absorbs both the ultraviolet and the visible radiations.

Knocking Due to Extension of Radiation

With one or two exceptions, said Dr. Clark, knocking seems to be due to the extension of the radiation produced by a knocking fuel into the ultraviolet region and to be produced during the first quarter of the stroke. Knock-suppressors, such as tetraethyl lead, aniline and iodine, have the effect of giving uniform radiation in all four quarters of the stroke. Alcohol fuel burns with greater heat than does gasoline and is the only fuel that emits radiations extending far into the ultraviolet without knocking badly. This may throw further light upon the hydroxylation theory.

The mechanism of radiation, said Dr. Clark, is that the radiation of short wave-lengths activates, or puts into an unstable condition, the molecules in the unburnt portion of the gas ahead of the flame; consequently, when the flame reaches that point they are ready to leap into action. A corollary of this is that agents like tetraethyl lead absorb the radiations that would tend to set into activity the molecules in the unburnt portion. This, however, is only part of the story.

Applications of X-Ray Examination

Stepping still further down into the invisible portion of the spectrum, the region of X-rays, Dr. Clark described the progress made in the examination of materials by X-rays, which, he said, were about 0.0001 of the length of ordinary light-rays. Among the uses he mentioned to which radiographic applications can be put are medical diagnosis; identification of persons; shoe fitting; examination of metal castings for internal gas cavities, sand and slag inclusions, pipe cavities, porosity, cracks, and metal segregation; welds, for soundness; control of the washing process for coal; classification of minerals; examination of the symmetry of golf-ball centers; adhesion of rubber to cords in tires; inspection of reclaimed rubber for nails and other metal content; inspection of insulated wire; the filling of grenades and shells; examination of the wood used in airplanes, for cracks, wormholes and knots; hidden wires and pipes in walls; mystery packages; Eighteenth Amendment contraband; internal diameters of metal pipes and capillaries; clogged gasoline feed-lines; the position of electrodes in vacuum tubes; examination of oil paintings, for retouching and for superimposed pictures; and the partial identification of pigments.

One firm requested a report on the size and location of holes in Swiss cheese, for the more "ragged" the cheese and the more full of holes, the more valuable it is. Another recent application described by Dr. Clark was a comparative study of carp from Illinois rivers, which showed the sick carp to be afflicted with a disease akin to rickets in children.

In the study of fine structures, Dr. Clark compared the X-ray tube to a small cannon, as it bombards the specimen under examination with negative electrons. Examination of structures with the tube discloses whether the material is crystalline or amorphous, macrocrystalline or colloidal; what is the lattice structure; the atomic and molecular arrangement and dimensions of crystals; the distances of nearest approach of molecules or aggregates in liquids, gels, and the like; the chemical identity, purity and phase structure; transformations and allotropic modifications; the chemical change due to aging; whether a crystal is single or an aggregate; the degree of fibering deformation and a quantitative analysis of the mechanism of deformation; the effects of fabrication, rupture, rolling, drawing, torsion, impact, complex deforming-forces, and the like; grain size; internal strain; differentiation between the surface and the interior; the thickness of films; the effect of low and high pressures and the nature of recrystallization; the uniformity of structure in different lots, in the same lot, or in the same unit; and fundamental differentiation between the same materials, with a determination of the satisfactory and the unsatisfactory properties for a given purpose.

Revelations Shown by the Slides

Slides were shown of the structures of iron, steel, copper and brass; their behavior under strains; the results of annealing; the regions of equal strength and the lines along which a casting might fail; the effects of rolling on hot-rolled and cold-rolled steel, and on the magnetic properties of nickel steel; the difference in structure of samples of dead-soft, soft, quarter-hard, half-hard and hard sheet-steel; the difference between ordinary arc-welds and the hydrogen-atmosphere welds under the same conditions of welding and when treated in the same manner; the structure of normal and broken steel-rails; duralumin subjected to different treatments; case-hardened steel and the method of improving the wearing qualities of spinning-rings; the

coating of an aluminum rectifier; enameling with dioxide of tin; the structure of asbestos and the adaptability of seven different kinds of asbestos to different uses; the organic compounds of hydrocarbons, such as paraffins, soaps, glycerids, greases, waxes, and the like; the conditions of satisfactory lubrication; the transparency of paraffin candles; the aging of the nitrocellulose base for Duco; the structures of cellulose, hemp, cotton, jute, and the like; and of rayon, silk, rubber, gutta percha, balata and varnish.

An interesting discussion followed which was participated in by R. E. Wilson, Walter Martins, G. R. Wilky, M. J. Kittler, B. S. Pfeiffer, and J. O. Eisinger. F. G. Whittington, chairman of the Chicago Section, presided.

MILWAUKEE HEARS RESEARCH MEN

W. T. Donkin Shows Valve-Spring Surge and W. S. James Speaks about Research

With Chairman Fred M. Young presiding, 55 members of the Milwaukee Section and 15 visitors met at 7:30 p. m. on Wednesday, Dec. 7, at the Milwaukee Athletic Club and, after electing a nominating committee for Section officers, listened to an appeal from Elling O. Weeks, of the Weeks Aircraft Corporation of Milwaukee, for better support of the local air-mail.

Milwaukee business men had promised 300 lb. of air-mail daily, but only about 22 lb. daily is being offered at present and there is danger of losing the route, according to Mr. Weeks, who predicted that next spring would see an airline between Milwaukee and Detroit if the city is willing to support it. By flying across Lake Michigan the distance can be made in 2½ hr. instead of the 12 hr. now required by rail.

Mr. Weeks said also that there will be a large demand for radial airplane engines of 50 to 60 hp. and 90 to 100 hp. for training purposes to replace the OX-5 engines, which are now becoming obsolete. To get a job, a pilot must have 50 hr. of solo experience. He gets only 10 hr. of this in training school at a cost of $25 per hr., and $15 to $25 per hr. makes this solo work too expensive.

The first speaker on the regular program of the meeting was W. T. Donkin, of the Cleveland Wire Spring Co., who presented slow-motion pictures of valve-spring surge and referred to tests[1] described at the last Semi-Annual Meeting of the Society. First were shown pictures of a valve spring designed by the engine manufacturers which caused much trouble from breakage and some from burned valves and the pounding of cams. The pictures were taken while the engine was operating over a speed ranging between 1400 and 2400 r.p.m., and a surge period appeared at about 800 r.p.m. but a change in speed of only 10 or 20 r.p.m. caused it to disappear.

The old conventional idea, said Mr. Donkin, was that it was best to use a large number of coils of large diameter to give a small stress-range. Such a spring does not meet high-speed conditions because of its low frequency, he asserted. When the spring is vibrating within itself, the stress range is greatly increased.

Failures Eliminated in Redesigned Springs

Pictures of a successful redesigned spring also were shown. The surge was not entirely eliminated but was reduced to such an extent that no failures resulted, according to the speaker, while the original spring would fail after 8 hr. running at 1400 r.p.m. Several changes were made in redesigning the spring, including a reduction in the diameter and the number of coils and in the diameter of the wire. The stress range was increased from 15,000 to 20,000 lb. per sq. in., according to the design.

In answer to questions from W. S. James and others, Mr. Donkin said that surge can be damped by a light touch of the finger or probably by running it in oil, but simpler solutions doubtless are available.

J. C. Slonneger, of the International Harvester Co., said that he found the oscillation to be readily damped out by contact with a small object such as a lead-pencil eraser. His experiments seemed to indicate that vibration periods come when there is an odd number of spring oscillations per camshaft revolution.

Variable-lead springs as used in some racing cars help the situation by allowing the coils to close sooner at the cylinder end of the spring, said Mr. Donkin.

Many valve-spring failures are traceable to surface defects in the steel wire. Following experiments with material from many European and American sources, electric-furnace chrome-vanadium steel wire is found to be the least subject to surface defects and gives the best average results of any material tried, when it is subjected to the proper heat-treatment.

Researchers Need Contact with Practical Problems

A talk on automotive research was given by William S. James, of the Studebaker Corporation of America, who expressed regret at the extravagant and misleading news reports of engineering subjects. Press notices of this sort hurt research and engineering, he said.

Research in industry is no different from Government research, and the value of the results is dependent upon the importance of the question investigated. It is important to have as close contact as possible between the research work and the actual practical problem. This helps to save time. One trouble with university research is that the professors and students are not in close enough contact with industry to know what are the current problems. Mr. James closed by saying:

> There is no mystery in research. Everything you can do to eliminate that misconception will help you and help the engineering fraternity in the automotive industry. If you submit any problem to a research man or a research organization, keep the man or the organization as close to the firing line as you possibly can.

FUTURE AUTOMOTIVE FUELS

Substitute Fuel Possibilities Discussed at Meeting of Indiana Section

Although the price of automobile fuel may increase considerably, the likelihood of the use of motor-vehicles ever having to be curtailed on account of lack of energy to run them is very remote, according to the conclusion of T. A. Boyd after reviewing the possible sources of energy in a paper which he presented at the regular monthly meeting of the Indiana Section at the Hotel Severin in Indianapolis on Dec. 15.

In his address, after pointing out that very nearly one-half the total of 804,000,000 hp. available through the agency of electric generators, steam and internal-combustion engines is provided by the motor-vehicle engines in service, the speaker reviewed the situation with regard to the supply of gasoline from petroleum; the increase in this due to improvements in the cracking process; the possibilities of production of shale oil, of liquid fuels from the carbonization of low-grade coal and of the use of powdered coal; the derivation of synthetic fuels by the new hydrogenation and other processes; the utilization of producer gas; production of fuel alcohol from vegetation; and use of the steam engine, of heavy-oil engines and of electric motors in motor-vehicles.

The general conclusion from the analysis given was that there does not seem to be any question about the adequacy of the sources of energy that can be used for automotive power, yet the automotive industry should take steps, said

[1] See The Journal, June, 1927, p. 722.

Mr. Boyd, to assure that its reserve of energy shall be usable; the problem is not one of supplying energy but the more easily solved problem of making it possible to convert potential energy into the form that will serve automotive transportation best. The directions along which this research should be conducted are (*a*) study of how to get more petroleum and to make the supply go as far as possible and (*b*) search for the solution of the obvious problems of making motor fuels from shale, coal and vegetation.

Among the many interesting statements made by Mr. Boyd was that gasoline contains a great deal more available energy than any of the high explosives, such as TNT, nitroglycerine and dynamite, because it does not contain free air; the motorist buys only fuel and gets the necessary oxygen for combustion in the 100 lb. of free air required for each gallon of gasoline. Another striking statement was that, inefficient as the internal-combustion engine is known to be, it is much more efficient than nature; it is at least 50 times as efficient as is the corn stalk or the wheat plant in utilizing the sun's energy.

Protracted discussion of this absorbing subject followed Mr. Boyd's presentation and was participated in by Chairman George H. Freers, William G. Wall, Thomas J. Litle, Jr., Mr. Boyd, Fred Duesenberg, Charles A. Trask, Ira C. Koehne, and E. S. Hall.

Truck Fields and Features

Past-President Bachman Surveys Requirements and Discusses General Mechanical Design at Dayton Section Meeting

Motor-trucks were surveyed comprehensively both as to their fields of usefulness and their design and operating characteristics by Past-President B. B. Bachman, engineer of the Autocar Co., at the Nov. 29 meeting of the Dayton Section.

Development of the motor-car has removed the restrictions upon movement by the individual, but this liberation would not be complete unless it were followed up by a transportation means that would supply him with the necessaries of life, observed Mr. Bachman. As a logical sequence, while there always has been a normal demand for an auxiliary form of transportation for merchandise, in addition to the main systems of mass transportation on land and water, the requirements produced by a dispersion of population due to the automobile have created an additional demand.

Primarily, the largest field of usefulness for the motor-truck is in this auxiliary capacity, but other fields exist in which it has been considered desirable to use the truck. It may be said, as a general statement, that the maximum field of usefulness is within a circle having a 50-mile radius which, under exceptional conditions, may be increased to perhaps three times this radius with satisfactory results.

To meet the requirements, it is necessary to develop different sizes of vehicle and a wide variety of types. The present requirements point to the need for greater flexibility, which probably will be met in the future by developments in the transmission system. Mr. Bachman said that he believes that we shall see further developments in the direction of 8 and 10-speed transmissions, in which the details will be worked out more satisfactorily than heretofore. An alternative system to the normal four-speed transmission with two sets of constant-mesh gears is one which would supplement the conventional gear-box with an additional unit having a direct and an indirect speed. This system, used in conjunction with the high-speed axle, increases flexibility of the unit as regards both speed and power, is less subject to derangement by ignorant operation, and the top gear is in direct drive, which, in conjunction with the high-speed axle, results in smooth, quiet operation.

Power-Driven Auxiliary Equipment Markedly Improved

In addition to the customary transport vehicle, a large number of trucks are required to perform specialized services, and for these purposes are equipped with power-operated dump bodies, pumps, winches, derricks for pole setting, power-driven post-hole diggers, and the like. Marked improvement in details of construction of this class of special equipment has been made in the last few years, as the economy of operation resulting from use of such equipment has created a demand that has been met by a number of companies specializing in the construction of mechanical bodies and auxiliary equipment.

In recent years we have seen also a tremendous development in first-class highways, which are as essential to efficient operation of the motor-truck as the road-bed is to the operation of railroad trains. The motor-truck has contributed its services in no small measure to highway construction but, unfortunately, has also been accused, sometimes rightly, of having contributed in as large a measure to the destruction of these roads. To meet this criticism and at the same time to provide for the hauling of heavy loads, the six-wheel vehicle has been developed and has met with some acceptance and recognition in several States by the passage of laws permitting trucks of this type to carry heavier loads than the customary four-wheel truck.

Desirability of Large Vehicles Questioned

It may be questioned, however, said Mr. Bachman, whether the increased cost and complication of the six-wheel construction is justified, and whether vehicles capable of carrying the larger loads are not in other respects objectionable on the highways, many of which are already uncomfortably crowded with traffic. This also raises the question whether congestion is not increased by the use of a larger number of smaller vehicles, but he was inclined to feel that much can be said in favor of the lighter vehicle, which can maintain its place in the traffic stream, as compared with the larger vehicle which becomes a menace at high speed because of its size and momentum and, unquestionably, causes congestion when traveling at slow speed.

Similar objections can be raised against the use of trailer and semi-trailer equipment; it has always seemed to the speaker that the function of this class of equipment is the operation of the power unit with one trailer or semi-trailer while other cargo units are being loaded or unloaded. Under such conditions, no doubt exists that the trailer or semi-trailer meets a real need in a very economical way. He always felt that it was unfortunate, said the speaker, that this class of equipment is often used continuously as a single unit, merely for the purpose of increasing the carrying capacity of the powerplant, as such units are more unwieldy than the six-wheel truck and the only advantage is that they make possible a distribution of the load on more wheels.

A certain amount of acceptance has been accorded the four-wheel-drive truck, which was designed primarily to

operate over bad roads. Some need always will exist for mechanical transport where the construction of first-class roads is not possible or not advisable, but efficient operation of the motor-truck depends, in general, upon good roads that are kept free of snow in winter. The importance of highway transportation will bring this condition into existence rapidly in areas where motor-trucking is largely required. When this condition becomes a reality, no reason will exist for the use of four-wheel drive except under the special conditions that occasioned its design.

Conventionality of appearance is a powerful sales factor, and in long-distance hauling the truck of conventional design, with the engine under the hood at the front, has been satisfactory and popular. Many advantages are to be obtained, however, from the construction in which the engine is under the driver's seat. This design results in a saving of approximately 3 ft. over-all length for a given length of cargo space, and with the same wheel tread effects a reduction in turning-circle diameter of about 15 ft. In construction work and operations that require loading and unloading in congested places, this type of vehicle meets a requirement which the speaker declared cannot be denied.

Although the four-cylinder engine is used almost universally, increasing consideration has been given in the last few years to the six-cylinder engine. This is due, in a large measure, to the development of the motorcoach and the adoption of the six-cylinder engine for this vehicle. The superior smoothness of operation of the six-cylinder engine is desirable in the lighter truck, and the demand for greater speed with larger vehicles probably can be met more satisfactorily with this type than by increasing the size of the four-cylinder engine. It remains to be determined, according to the speaker, what size of six-cylinder engine should be installed in a truck of a given size as compared with the four-cylinder engine previously used. The torque output per cubic inch of the former is no greater than that of the latter and, while the horsepower curve is steeper and the output greater, and while it is possible to run the six-cylinder engine at higher speeds due to the lighter reciprocating parts and better balance, it is questionable if the increase of gear-ratio to obtain the better acceleration desired would be a satisfactory solution. Mr. Bachman believes that all six-cylinder engines would have to be at least 15 per cent larger in piston displacement than the four-cylinder engine to give satisfactory comparative performance.

The characteristics of the single-plate clutch are superior to those of the multiple-disc clutch, particularly as regards heat dissipation, in the author's opinion.

Worm-Gear and Chain-Drive Applications

For final drive, the enclosed axle is used on the great majority of trucks, and in the smaller sizes up to possibly 2-ton capacity a single-reduction axle having a spiral-bevel gear-drive has been applied successfully. Axles of this type for larger sizes of truck are subject to criticism on the ground of the large size of bevel-drive gear necessary to obtain the required gear reduction and the difficulties which this size creates in properly taking the end thrust of the ring-gear. It seems entirely practicable, however, to produce a satisfactory axle of this type with a spring-pad capacity of 7500 lb. and with gear reductions up to 7 to 1. So far as he knows, Mr. Bachman stated, no actual developments have been made toward the use of the hypoid gear in the larger trucks. The development of the cord tire resulted in the introduction of large-sized pneumatic tires for the heavy loads incident to truck service. Recently the revival of consideration of the dual pneumatic tire, which makes possible the use of a single size on all wheels, has tended to increase the popularity of the pneumatic tire for the larger vehicles; in many instances the pneumatic tire is being used successfully on vehicles of 25,000-lb. gross weight.

B. B. Bachman

This success of the dual pneumatic tire has been dependent upon the general improvement of the roads as well as the tires.

At present the most pressing problem is the development of satisfactory wheel equipment for the mounting of tires. Competition between different forms is exceedingly keen, as the demand is active, and the near future undoubtedly will see the survival of only the most suitable types.

Another problem created by the dual pneumatic tire is the construction of axles to obtain proper trucks. Both the double-reduction axle and the worm gear have been developed successfully for use in units of from 2 to 5-ton capacity, a very satisfactory construction being the double-reduction axle with all gears mounted on a carrier at the center. Gear ratios of approximately 10 to 1 can be obtained readily without undue size or weight.

Chain drive still survives for vehicles of more than 5-ton capacity, and its principal competitor is the worm gear, which has the advantage that the working parts are enclosed and protected from dirt and operate in a lubricating bath. Chain-drive construction has the advantage of giving greater ground clearance of the vehicle and lighter unsprung weight.

Problems Created by Pneumatic-Tire Use

Remarkable improvement in the life and general characteristics of the solid tire has been made in recent years, and special forms termed cushion tires have been developed which approximate the performance of pneumatic tires at moderate bearing mounting for the wheels. This is largely a matter of detail, but involves changes in construction that are expensive, both from the manufacturing and the service standpoint.

Improved Steering-Gears Reduce Driving Effort

Growing use of pneumatic tires also produced a demand for improvement in the steering mechanism in trucks. Several steering-gears have been developed during the last few years that incorporate features of reduction in steering effort, together with long service life, in a very satisfactory way. With these mechanisms, advantage is taken of the possibility of producing a variable reduction in different parts of the wheel travel. In one make, by means of a variable-pitch screw or cam, the gear reduction is high in

and near the straightaway position and speeds up as the wheels are cramped into full lock. In another make, by taking advantage of the travel of the crank, the opposite condition is obtained. Both systems seem to operate satisfactorily in service, but the second type is much easier to operate where a considerable amount of backing or maneuvering in close quarters is necessary.

Steering-gears are made at present that require from three to four turns of the steering-wheel to swing the front wheels of the vehicle from one extreme position to another, as compared with 2 to 2½ turns regarded as the maximum desirable a few years ago.

Servo brakes and pneumatic or electrically operated gearshift mechanisms have been proposed to relieve the driver of a large part of the manual effort necessary to operate large vehicles, but Mr. Bachman knows of no one who has adopted a mechanism for steering the vehicle mechanically, although one mechanism for this purpose mounted on a Stutz car was demonstrated at the Summer Meeting at French Lick Springs last May and its general performance seemed very satisfactory. If such a device can be developed that will be mechanically sound, it seems that it would fill a very real need.

Braking Problem Tied Up with Linings

Demand for higher truck speeds, the growing density of traffic, and the better brake control of passenger-cars as a result of the advent of four-wheel brakes, have directed more attention to the improvement of the truck's system of brakes. Several makers of vehicles up to 2-ton capacity have applied four-wheel brakes, but the system has not come into use on larger trucks, although it is in use on large motorcoaches. The speaker doubted whether satisfactory mechanical four-wheel brakes can be applied to the larger motor-trucks. Specialists in this line claim that it can be done, but Mr. Bachman raised the question whether, in developing brakes with a sufficient servo action to keep the pedal pressures within moderate limits, the design will not be subject to uncertain operation due to variations in brake-lining coefficients. If work that is now being carried on actively, to further improve brake linings in the matter of maintaining a uniform coefficient of friction, results successfully, it is possible that mechanical brakes may be developed that will take advantage satisfactorily of the better brake-lining characteristics. Otherwise, the use of power brakes or booster mechanisms will be the only available avenue of immediate improvement.

General Service-Stations Are Needed

The question of operation and maintenance is of at least as much importance as the design and manufacture of the truck, asserted the speaker, and it is unfortunate that, in general, operation and maintenance have not been so efficiently organized as manufacture, although highly commendable efforts have been, and are being, made by various organizations that are manned by superior personnel and directed by men who have devoted much study to this important matter. The increase in efficiency and effectiveness in many large fleets in many parts of the Country bear testimony to the broad conception these men have of the problem. A large number of vehicles operated in small groups, however, in many cases receive little or no skilled attention, and facilities for such attention have not been provided in many places where considerable sales activity is being carried on.

It is a question, said Mr. Bachman, whether the truck manufacturer alone can develop these facilities. In many localities the business in any one make of vehicle probably is not sufficient to support adequate service facilities for the operator who does not have a large enough installation to enable him to provide such facilities for himself. For this reason, the future seems likely to see the development of service stations whose facilities can be used for the servicing of various makes of vehicle. Such a development unquestionably will be attended by many problems, but Mr. Bachman feels that the need for such facilities will become increasingly apparent and will offer a field of activity for a new type of automotive engineer. He believes that its successful operation offers sufficient reward to attract men of the highest abilities. This fact has been recognized by the Society and the Sections, and the success of its Transportation Meetings, the enthusiasm of the members of the Operation and Maintenance Committee, and the program which they have outlined for their future activities, bear testimony to this fact.

ENGINE AND CAR PERFORMANCE

W. S. James's Paper Presented to Metropolitan Section After an Enjoyable Dinner

Items that are dependent upon engine design and which are considered in the paper on Engine and Car Performance, by W. S. James, research engineer for the Studebaker Corporation of America, include acceleration, hill-climbing ability, fuel consumption, and maximum speed. The paper was presented by the author at the meeting of the Metropolitan Section held at the Hotel Woodstock, New York City, on Dec. 15 before an audience of nearly 200 members and guests. The technical session, presided over by E. F. Lowe, general manager of the K P Products Co., followed a most enjoyable dinner at which 137 participated.

Other factors entering into both engine and car design are the size and speed of the engine, its compression ratio and the weight of the car. The paper and the discussion which followed its presentation are printed in full elsewhere in this issue of The Journal.

Among the features of entertainment which attended the occasion was a humorous address by Raymond Hitchcock, theatrical star, who facetiously presented his qualifications as a nominee for the presidency of the United States. Another feature of interest was a somewhat detailed description by F. K. Glynn, of the American Telephone & Telegraph Co., of the program of events for the Annual Dinner of the Society to be held at the Hotel Astor on Thursday, Jan. 12.

Another event of importance during Automobile Show Week in New York City is the "Open House" to be held by the Metropolitan Section at the Hotel Commodore on Jan. 9. The various automobile companies will be represented at the speakers' table by their chief engineers, who, following the dinner, will summarize briefly the leading engineering developments at the Show. Owing to the large number of those who are planning to attend this dinner, it is important that reservations be made well in advance so that a definite seating list can be arranged.

NEW COACH INTERESTS CAPITAL SECTION

Frank Fageol spoke on the subject of The Twin Coach at a meeting of the Washington Section held on Dec. 2 at the Racquet Club in the City of Washington which was attended by 40 members, 20 of whom partook of the members' dinner preceding the technical session. Following Mr. Fageol's discourse, all of the attendants at the meeting were taken in the Twin Coach operated by the Capital Traction Co. to the local plant of the Ford Motor Co. as a demonstration of the motorcoach. At the Ford plant the members inspected the new Model A Ford, which was put on exhibition on the day of the meeting.

Secretary E. F. Pardoe, of the Washington Section, reports that Chester H. Warrington, of the Warrington Motor Car Co., was elected to serve as alternate on the Nominating Committee of the Society in the event that A. W. Herrington is unable to serve as a member.

Tire Making and Size Simplification

Cost Reduction Through Better Manufacturing Partly Offset by the Cost of Needless Sizes—Detroit Section Sees Production Methods

Preliminaries to the technical session of the Detroit Section meeting on Nov. 21 were a visit to the Detroit plant of the United States Rubber Co., the usual dinner at the Book-Cadillac Hotel, at which an excellent entertainment program was rendered, and a business session devoted chiefly to membership matters. Chairman Walter T. Fishleigh called upon H. A. Hansen, secretary of the Section, who explained that men who have charge of technical service and of large fleets of motor-vehicles are good prospective members.

F. K. Glynn who was asked to speak as chairman of the Membership Committee of the Society and chairman of the Metropolitan Section last year when that section made such a phenomenal membership gain, said that every new member of the Society in the Metropolitan district last year was secured as a member of the Metropolitan Section and that the Detroit Section has an opportunity to secure members enough to out-distance the "Met" Section in the race.

L. Clayton Hill was welcomed back into the Section and he congratulated the officers on the Section's remarkable accomplishments of the year. W. G. Wall, nominee for President of the Society, extended greetings from the Indianapolis Section.

Burton J. Lemon, one of the hosts of the Section at its afternoon visit to the United States Rubber Co., presented the leading paper of the evening on the subject Tire Production Progress and Size Simplification. This was divided into three parts: (a) production of rubber, (b) manufacture of tires and (c) tire-size simplification.

In 1900, according to the paper, South America produced and North America used one-half of the rubber of the world. Now, 94 per cent of the rubber comes from the Far East and only 4 per cent from South America. The United States Rubber Co. started a rubber plantation in South America in 1903 but abandoned it a few years later in favor of production in the Far East on account of more stable government and better labor conditions. Plantations now owned by the company on or near the island of Sumatra total 136,000 acres and represent an investment of $28,000,000. While they do not supply all the crude rubber needed, they serve also as centers for the purchase of rubber produced under known conditions. Although located so near to the equator, sanitation has eliminated several of the common diseases of the tropics and secured a very low death rate for the workers. Scientific propagation and care of the rubber trees, notably selective budding, have resulted in a yield of three times the average secured from ordinary trees.

Latex Coagulated by Spraying

Great progress has been made in handling the latex, which consists of about 30 per cent of rubber in the form of minute globules, 66 per cent of water and 4 per cent of other substances. The injurious coagulation by acids has been replaced, explained the author, by a spraying process in which the latex is poured on rapidly rotating horizontal discs from which it is sprayed through heated air upon a moving conveyor, the water being evaporated in the process. Uniformity of product is secured by mixing large quantities of latex from different sources.

Previous to 1880, most of the rubber produced was used for footwear. Tires for bicycles changed this condition and now 60 per cent of the rubber produced is used in the 62,000,000 automobile tires produced in America during the year, valued at $920,000,000.

Owing to the improvement in manufacturing processes, 40 workers now can make as many tires as 100 could make 10 years ago. The factory space needed has been reduced greatly by the use of conveyors. As a result of these factors, the potential yearly tire production of the Country is about 82,000,000 casings. Thus the tire industry, like many other industries, is over-capitalized.

Although cord fabric tires first were made in 1894, automobile tires were made in the United States from woven fabric until 1914, when some automobile tires were made with two plies of very large cords. With large production, experiments proved the superiority of cord tires. Some of the large manufacturers now own cotton mills in which their cord fabric is made under their own control.

Recent Improvements in Tire Making

Another great improvement in the manufacture of tires is the use of latex for impregnating the web cord. Although latex is a 30-per cent rubber compound, it wets and flows like water, while a 10-per cent rubber cement is thick, like molasses. This assures an impregnation such as cannot be secured by rolling rubber sheet into the fabric. In this process, the cords are passed slowly side by side between spacing pins, from creels, through a bath of latex and over large heated drums which dry out the water and leave virgin rubber holding the cords in a firm sheet. This makes unnecessary the weft cords that are part of the older type of cord-tire fabric.

The flat-band method of building cord tires is an important improvement which results in better tires, according to Mr. Lemon. When built over a core, the tension of the tire cords depends largely upon the strength of the workman and is likely not to be uniform. When the tire is built as a flat band and brought to shape by air pressure before vulcanizing, the cords adjust themselves to uniform tension.

Other manufacturing improvements are the Banbury rubber mixer, which handles large batches more accurately than mixing rollers can handle smaller batches; extensive use of conveying equipment; and great improvement in the generation of power, the cost of which is a large percentage of the total budget of a rubber factory.

Simplification of Tire Sizes

Mr. Lemon characterized the cost of marketing balloon tires as a disgrace to the intelligence of American business. There are balloon tires that differ in section diameter by as little as ¼ in., and the unnecessary sizes lock up an enormous amount of capital in manufacturing equipment and stocks, as well as in tires, wheels, rims and tire carriers. To simplify or not to simplify is the leading tire question.

Multiplication of tire sizes tends to "profitless prosperity," continued the speaker. During the war 100 sizes of tires were in use. A reduction to nine standard sizes helped the prosperity of both the manufacturer and the dealer. At first there were only four sizes of balloon tires; now there are 40 sizes, but 80 per cent of the production is on only four of them. The tire dealer is bewildered by the multiplicity. He cannot stock half the sizes in current use nor make a livable profit on his large investment. He cannot even fill his orders without consulting a tire dictionary.

A simplified list of sizes has been adopted tentatively after conference between the division heads of the Rubber Association of America, the National Automobile Chamber of Commerce and the Tire and Rim Division of the S.A.E.

Standards Committee. Secretary Hoover has planned a campaign to help secure its effective adoption. The time is ripe, said Mr. Lemon, for reduction in the cost of motoring by such a simplification.

Rim Fits Can Be Standardized

Following the presentation of Mr. Lemon's paper, written discussion by H. M. Crane, chairman of the Tire and Rim Division of the Standards Committee, was read by John H. Hunt, president of the Society. After referring to the tire-size standardization during the war, Mr. Crane asserted in his statement that, up to the present time, low-pressure tires had not reached the period of engineering development when they could be standardized. The recent demand for smaller wheels, for the sake of appearance, has further complicated the question. However, no further gain in appearance can be had by further reduction of wheel size with retention of the standard tread.

Any attempt to standardize tires themselves at present is thought by Mr. Crane to be useless. For one thing, tires of different load capacities are demanded for the same size of rim, and some cars use five-ply tires for the front and six-ply tires for the rear wheels. Another difficulty is that when the weight of a certain model of car is increased it is cheaper to change the rim to accommodate the tire of larger section than to change the body and fenders. It has been found that the same tire can carry a greater load when mounted on a wider rim. Economic pressure forces manufacturers to take advantage of this and it is a question whether the loss in distributing cost counterbalances the gain.

Proposed new standards[1] for passenger-car rim sizes have been decided upon and it is expected that they will be presented to the Society by the Standards Committee for approval at the coming Annual Meeting.

Standardization never is successful except as it is the result of experience. Mr. Crane believes sufficient experience has now accumulated to attempt the elimination of unnecessary sizes. The tire user is not yet interested in the question and it will be several years before any simplification, no matter how successful, will show much result in the field, but the sooner it is begun the sooner some advantage can be reaped.

A New Tire Model Every Week

T. G. Graham, works manager of the B. F. Goodrich Co., presented charts showing the sizes of tires now being produced, together with their carrying capacities and loaded radii. He said it is necessary to consider the question humorously, as the sizes had been developed in such a haphazard way. He corrected Mr. Lemon's figure for the number of different sections and diameters of rims, saying that another had been designed last week that Mr. Lemon failed to include. If a Friday passes in the factory without a rush order for a new size of tire to be built over Sunday, the production department thinks something is wrong.

When asked his opinion of a program to simplify balloon-tire sizes, the Goodrich sales manager said that only 3 per cent of the dealers have sufficient capital to carry a complete line of tires and those few are not so foolish as to do it. As the dealers do not carry all sizes, it becomes necessary for the manufacturer to have about 150 depots in the Country carrying an average of about 10 tires of each size. It is estimated that the Goodrich company has in its inventories slow-moving tires to the value of about $15,000,000.

Material represents about half of the cost of a tire to the dealer. Mr. Graham estimates that the simplification of sizes might reduce the total cost of tires by as much as 10 per cent, resulting in the possible annual saving of $100,000,000 three years hence.

Ray M. Hudson, assistant director of the Bureau of Standards, opened his talk with a variation of the $2\pi r$ formula. In promising a brief speech, he reminded himself that "the longer he spoke, the greater the tire."

Complete adherence to any standardization plan cannot be expected, but in a recent survey of 80 programs of the sort it was found that an average adherence of more than 80 per cent has been secured in 22 of the lines represented. The need for tire-size simplification is evident. Even the motorist is beginning to realize the burden. Perhaps the condition is due to sales departments, which always want something new.

There is now more competition, according to Mr. Hudson, between the entire automotive industry and other industries than there is between different makers of cars. Instances of this are the advertising campaigns being carried on by organizations like the Better Homes of America and a National association of lumber manufacturers which is spending $1,000,000 annually to promote increased use of lumber in house building. Most of these industries are competing for a portion of the customer's dollar that now is being spent with the motor-car industry.

Tire-size standardization should not be like Mark Twain's characterization of the weather, when he said "Everybody talks about it, but nobody does anything about it." When the representatives of the Society and the tire industry agree on a list of sizes, the Bureau of Standards will help to get them adopted in practice. Such programs have been effective in the past. Eleven industries that have completed simplification programs, in the introduction of which the Bureau has cooperated, report annual savings of $300,000,000. They say they could not have done this without Government help such as the Bureau of Standards is ready to give to the automotive industry.

SIX-WHEEL-VEHICLE DEVELOPMENT

Northern California Studies Fundamentals of Suspension, Driving and Braking

Details of the principles governing the design of six-wheel motor-vehicles were presented by Arthur H. Lacey, consulting engineer of Los Angeles, to the members and guests of the Northern California Section at the meeting held on Dec. 8 at San Francisco. W. S. Penfield, chairman of the Section and superintendent of shops for the Associated Oil Co. of San Francisco, presided at the technical session, which followed a members' dinner at the Engineers' Club. The author's presentation of his paper included numerous lantern-slide illustrations of the types of vehicle he analyzed and, preceding the general discussion, Ethelbert Favary, chairman of the Southern California Section and consulting engineer for the Moreland Motor Truck Co., presented his points of agreement and disagreement with Mr. Lacey's analysis of the subject, also illustrating his remarks with lantern-slide views.

Six-Wheel Design Problems Classified

Classifying the design problems of six-wheel vehicles as (*a*) suspension, (*b*) driving means and (*c*) braking means, Mr. Lacey said that these problems are related very closely and depend upon one another to a considerable extent, but that many forms of suspension can be combined readily with various forms of drive, and vice versa. He enumerated these forms of suspension and commented upon their respective merits, then discussed the subject of four-wheel drives, illustrating the various types by lantern slides and describing their major features.

Included in this portion of his paper was a discussion of a design of vehicle having front-wheel drive. This consisted of two worm-drive axles coupled together with a short propeller-shaft, the forward axle being coupled also to the transmission with a short propeller-shaft. The engine is mounted in the chassis with its flywheel end toward the front. The transmission has a helical-gear drive down to the propeller-shaft and the front wheels are driven from

[1] See p. 120.

the differentials through universal-joints. The torque reaction is absorbed by a pair of springs on either side, mounted on hangers, and the drive is transmitted to the frame through the springs. Mr. Lacey also described other special types of design, inclusive of several types of trailers.

In discussing the principles of governing the equalization of load-distribution, Mr. Lacey said that all four-wheel rear-ends have or should have some means whereby the load is distributed between the two wheels on each side of the vehicle. This requires some kind of equalizer, the primary purpose of which is to permit the wheels to rise and fall while passing over road irregularities, maintaining at all times the proportion of weight distribution which is desired. He stated that this principle has been utilized in railroad equipment for many years. This equalizer not only performs the function of distributing the weight between two wheels while allowing them to rise and fall as the wheel progresses along the road, but it also performs the important duty of reducing impact shock considerably. In treating this phase of the equalizer's functions fundamentally, the speaker said that numerous variable conditions should be assumed not to exist. This assumption is necessary, not because these variable conditions are unimportant, but because, in the fundamental consideration of the equalizer's effect on impact values, it is not feasible to assume values for widely different conditions. Among the differing conditions which depend upon the particular design of suspension are the inertia of the unsprung parts, spring characteristics, and the position of the trunnion bearing.

Other features of Mr. Lacey's paper were discussions of torque reaction and the equalization of the driving effort between the four wheels of four-wheel-drive systems. This last is not done to better the steering conditions but to allow for differences in tire diameter and air pressure as well as to assure equal torque among the four wheels. On the subject of brakes, the speaker said that some designs of six-wheel vehicles have brakes on two wheels and some are braked on four wheels. If it is necessary to drive on four wheels, it is more necessary to brake on four wheels. The details and merits of various types of braking system were next discussed.

In conclusion, Mr. Lacey emphasized the importance of striving to maintain the same ground pressure, the same torque, and the same braking upon all four wheels, so as to keep the inertia of the unsprung parts at the minimum. He said that this is more important out toward the wheel than it is close in to the trunnion bearing. It is also important to make the equalizing action free from restraint.

Additional Six-Wheel-Vehicle Data

During his talk, Mr. Favary showed lantern slides of six-wheel vehicles used by the Government and read a summary of the advantages of the commercial six-wheel truck as made by a member of the Quartermaster Corps, U. S. A., Camp Holabird, Md. This summary had to do with adaptability, safety, traction, wheel-spin and fuel consumption. Mr. Favary then said in part that, in considering six-wheel-vehicle design, figures obtained from actual conditions should be used rather than that figures be assumed. He discussed wheel and tire slippage, demonstrating by sketches the principles involved. The maximum wear on dual tires is great, he explained, because for much of the time the whole load is carried on one tire instead of on both tires; one tire may be softer than the other, in which case the other of the dual tires must carry the entire load. He then described a design which assures that 50 per cent of the load will be carried on each set of tires. He also described a type of mechanical braking system that is applicable to six-wheel vehicles.

Responding to Mr. Favary's remarks, Mr. Lacey explained that because his time was limited he had, in the delivery of his paper, omitted some of its features. A discussion followed between Mr. Lacey and Mr. Favary on various debatable points such as wheel and tire slippage, theoretical versus practical features, tire mileage, and brakes.

CLEVELAND SECTION HEARS DICKINSON

Chief of an Important Division Tells about Bureau of Standards Men

After a dinner and "Beauty Show" at 6:30 p. m., the Cleveland Section met in Carnegie Hall on Dec. 19 to hear Dr. H. C. Dickinson discuss research work and research men who have been responsible for the accomplishments of the Bureau of Standards. Chairman S. L. Bradley presided at the meeting, that included a business session at which five members were elected as a committee to nominate Section officers for next year.

In opening his address, Dr. Dickinson said that about 10 years ago research was not considered an interesting subject. Conditions have changed, however, and now every organization has a research laboratory and is doing research work. The term "research" applies to everything from the work of an Einstein to that of a clerk who selects references from the trade journals. We generally think of research as the work that goes on in laboratories such as are shown in university catalogs, but the essential element in research work is not the mechanical equipment but the man.

Dr. Dickinson then showed on the screen photographs of a number of the leading men in the history of the Bureau of Standards, beginning with Dr. S. W. Stratton, the first head of the bureau, and Dr. G. K. Burgess, its present head, and including a number of department heads and research men who have made outstanding contributions, particularly those who have worked on problems connected with the automotive industry.

The portrait of each man was left on one half of the screen while apparatus representing some of the man's work was shown beside it. The photographs shown and much of the address were the same as given at the Nov. 29 meeting of the Metropolitan Section, reported elsewhere in this issue of The Journal.

Credit cannot be given justly to one man alone for many of the accomplishments mentioned, Dr. Dickinson explained, since most of them were the result of collaboration.

One of the slides was a chart showing the distance required for stopping various motor-trucks and passenger-cars from a speed of 20 m.p.h., the data being secured from about 400 tests gathered at random in different cities, as Boston, Baltimore and the City of Washington. The results were poor, particularly for trucks, none of which was able to stop within 30 ft. and 37 per cent of which required more than 100 ft. with the foot brake applied.

Poor Adjustment of Brakes Demonstrated

Responding to a query by B. H. Blair, of the Eaton Axle & Spring Co., Dr. Dickinson expressed his opinion that every passenger-car on the market is capable of meeting the ordinary requirements of stopping within 50 ft. from a speed of 20 m.p.h., and that most of the failures are due to poor adjustment. The same is not true of motor-trucks, but probably all of them can be stopped within 50 ft. with the use of both hand and foot brake, providing both are in proper adjustment.

Dr. Dickinson's proposed rule for safe driving was mentioned by E. W. Weaver, of the George Trundle, Jr., Engineering Co. This proposed rule will be recalled by most of the members of the Society as stating that a car must be so driven that it can be stopped within the space which the driver knows is and will remain clear.

In amplifying this, Dr. Dickinson said that certain right-of-way rules must be depended upon and that general interpretations of these rules would be of great assistance. A vehicle going directly ahead along a main highway always should have the right of way over everything else except at certain crossings. The arterial highway should have the right of way in both directions.

At intersections on various highways are signs that say "Stop." The real meaning of these signs is that a driver enters the intersection at his own risk; he does not have the right of way. Many drivers observe the letter of the law by stopping but still do not take the warning in a way to make it an effective safety measure. When it is necessary to cross a busy highway from a street where the driver has not the right of way, he edges up until he sees an opening and then signals. Other drivers slow up as a matter of courtesy to let him pass. Without this procedure, no driver could cross a busy highway, but this situation does not seem to be recognized in any of the legalized traffic codes.

CAUSES OF CYLINDER WEAR TOLD

Factors Contributing to Lack of or Poor Lubrication Listed at Buffalo Meeting

Lack of sufficient lubrication, resulting in more or less metal-to-metal contact, is the fundamental cause of cylinder-wall wear, the members of the Buffalo Section were told by H. L. Newton, of the Vacuum Oil Co., at a meeting held on Dec. 6, which was attended by 70 members. If a perfect oil film could be maintained between the sliding surfaces, thereby positively eliminating contact of metal to metal, no wear would result and the pistons and cylinders would remain in perfect mechanical condition indefinitely. Engine temperature, surface pressures and many other contributing factors tend to reduce the condition of ideal lubrication to the condition with which we are more accustomed to deal.

Analysis of complaints and problems in the field covering a period of time gives a fair picture of the reason, causes and remedies for excessive wear on the cylinder-walls. With the aim of approaching the ideal conditions and maintaining it as nearly as possible, the first procedure is to select a lubricant that is suited to the mechanical and operating peculiarities of the given engine. This lubricant must have quality and must be of a body and character to meet the engine requirements and must be maintained in good condition and supplied in sufficient volume to the friction surfaces to meet the needs. When such a lubricant is used, however, some difficulties will still arise. Outside deteriorating influences make themselves felt and tend to destroy the film that has been provided as a preventive of wear. Most of these factors are born of unintelligent or careless operation of the engine, but a few are the result of certain features of design. Research and the analyzing of complaints received from operators during a period of years prompted the company with which the speaker is connected to list its findings and to pass them on to automotive engineers for their comment and discussion. These factors contributing to cylinder-wall wear were listed as follows:

(1) Excessive use of choke, more or less necessary when starting chilled engine
(2) Engine operated for a period with choked air-cleaner
(3) Operating engine with choke partly on
(4) Badly diluted crankcase lubricant
(5) Operating engine without air-cleaner in abrasive-laden atmosphere
(6) Racing engine when starting from cold
(7) Failure to drain crankcase in proper manner to assure removal of abrasives in the lubricant. Neglecting to clean filter
(8) Sludge and oil emulsion
(9) Crankshaft main-bearing-groove practice; short registering grooves
(10) Excessive ring pressure
(11) Continued use of a lubricant of poor quality which does not meet engine requirements as to body and character, which is not maintained in good condition, or which is applied to the friction surfaces in insufficient volume

In the discussion following the presentation of the paper by Mr. Newton, Gustaf Carvelli, of the Curtiss Aeroplane & Motor Corporation, remarked that the automotive engineer has done a great deal to overcome lubrication troubles by providing shutters to raise the water temperature quickly in cold weather and thermostats to maintain uniform temperatures. Moreover, provisions have been made to cool the oil in the engine when it becomes too hot and to heat it when it becomes too cold. Despite these devices, it is rather difficult, he said, to select an oil that is best suited to the engine under all conditions, and Mr. Carvelli said he believed the oil manufacturers should supply an oil having the same viscosity at both low and high temperatures. Present oils vary too much in viscosity at different temperatures; car operators cannot be expected to run an engine for 10 or 15 min. to warm it up before starting in the morning.

How Car Operation Affects Dilution

Dilution of the oil is not the cause of trouble in engines asserted John C. Talcott, of the Pierce-Arrow Motor Car Co., who said that in some tests made by the company about a year ago a car that was stored in an unheated garage was driven about 1 mile in the morning, then allowed to stand out of doors until noon, when it was run 1 or 2 more miles, after which it stood outside until evening and was driven 1 more mile. A dilution of 14 per cent was obtained in 1 day on such a schedule but if the same car were run at 40 m.p.h. for 1 hr. the dilution would be greatly reduced. He thought that 14 per cent dilution does no harm and that an engine starts harder on fresh oil than on oil that is diluted a little. In a car that was run on three 8-hr. shifts a day, covering 175 miles on each shift, a quart of kerosene was put in the oil at the beginning of each shift, and the dilution was driven off. Mr. Talcott said that he was interested in Mr. Newton's remarks because, for one thing, the changing of the oil every 200 miles was not advocated. He stated that an engine has been run by the Pierce-Arrow Company for 42,000 miles without changing the oil and with the addition of only 1 pt. of oil every 175 miles.

Donald S. Cox, research engineer of the same company, remarked that he was interested in a suggestion made by Mr. Newton to heat the engine before starting, and that he understood that in England a safety lamp is hung under the engine hood during the night to keep the engine warm. Along this same line J. W. White, of the Wire Wheel Corporation, stated that Harry House, who works in the corporation's plant, attaches a 110-volt resistance wire to the carbureter in his car in some manner and runs the wire to a switch in his house. When he gets up in the morning he turns on the switch, eats his breakfast, and when he goes out to the garage he pulls out the plug and the car is ready to drive to work.

Animal Oil Clings to Hot Metal

Asked by W. W. Slaght, of the Pierce-Arrow Company, what he knows about the effectiveness of oleic acid for resisting friction in an engine, Mr. Newton replied that he could not give much information regarding it but that there are some compounded oils which are claimed to have an advantage. E. H. Coburn, of the Ajax Oil Co., remarked that an oil is being marketed that contains animal fat; that it is well known that a mineral oil is driven away from hot metal whereas it is claimed that if oleic acid is introduced the oil will cling to and penetrate the surface of the metal.

With regard to dilution he asked Mr. Newton how the heavy ends of gasoline that drain down into the crankcase and require a temperature of 300 to 400 deg. fahr. to vaporize them can be eliminated from the crankcase at an

operating temperature of only 200 deg. fahr. To this Mr. Newton replied that it is possible to reclaim oil by agitating it with steam and that agitation of the oil in the crankcase, together with circulation of fresh air in the case, drives off the heavier ends of the fuel and that the 3 or 4 per cent of heavy residue that cannot be driven off does no harm. Although a high crankcase temperature usually is desirable, it is necessary or advisable sometimes in extreme cases to have an oil cooler to lower the temperature of the oil.

Referring to Mr. Carvelli's statement that it would be desirable to have an oil that would have one viscosity at all temperatures, Mr. Newton stated that this is not possible. The oil companies refine oils to have certain qualities for specific purposes. Commenting on Mr. Talcott's citation of running an engine for 42,000 miles without draining the crankcase, he said that oil itself does not wear out; that it is the outside influences that affect it mostly, and that in the case mentioned the temperature of the engine must have been sufficient to exclude foreign elements, enough fresh oil being added merely to maintain the proper oil level.

Front-Wheel-Alignment Problems

Southern California Section Hears Several Papers on Causes and Cures of Tire Wear and Wheel Shimmy

Camber, caster, toe-in, and other factors of front-wheel-alignment problems as they affect tire wear and steering ability were main subjects treated in the several papers which were presented at the meeting of the Southern California Section held Dec. 2, at the City Club, Los Angeles. The technical session was presided over by Ethelbert Favary, chairman of the Section, and was preceded by a dinner attended by nearly 250 members and guests.

Because of the large number of non-members present, a special meeting was held to elect a representative and an alternate to serve on the Nominating Committee of the Society. William M. Britton, consulting engineer, of Los Angeles, was elected representative, and Charles H. Paxton, instructor in heat engines and machine design at the University of California, Southern Branch, was elected alternate. This action is to be approved at the next regular meeting of the Section.

Three papers on front-wheel alignment were presented, these being by J. E. Van Sant, superintendent and service manager of the Paul G. Hoffman Co.; by F. S. Hoover, shop superintendent of the Southern Counties Gas Co.; and by J. S. Bushey, of the J. S. Bushey Co. A paper on the Effect of Front-Wheel Alignment on Tire Wear, and the Various Causes of Front-Wheel Shimmy, by J. E. Hale and C. R. Stewart, of the Firestone Tire & Rubber Co., was read by F. W. Stavely, who also is connected with that company. Descriptions of several devices for determining proper front-wheel alignment were given by those who represented them, and short talks were made by others regarding methods of front-wheel alignment, straightening of axles and the like.

Should Rely on Manufacturer for Alignment

Mr. Van Sant said in part that proper front-wheel alignment is necessary to secure satisfactory steering-ability and tire mileage; and that details of the methods by which alignment is secured must be known, as well as the methods by which misalignment can be corrected. It seems to him most logical to depend upon the automobile and the tire manufacturers to provide proper front-wheel alignment because they are the ones most vitally interested in having their products perform satisfactorily. As to the methods of determining what the actual amounts of camber, caster, toe-in and the like should be, the speaker said that alignment can be checked for accordance with the manufacturer's specifications and tolerances without the use of any expensive special equipment.

Regarding the methods for correcting misalignment of front-axle parts, one indisputably satisfactory method is to replace the damaged part with a genuine new part. A second method is to straighten the part while cold and thus bring it back to correct alignment. In case the part is too badly bent to straighten while cold, it is best to replace it, he said. A third method is to straighten a part after it has been heated; but this method is subject to various restrictions as to the degree of heat that can be employed safely and as to the strength of parts after they have been heated. It is Mr. Van Sant's opinion that the real problem now is how to assure the motoring public of satisfactory tire mileage and steering ability without excessive expense.

Improper Toe-In or Toe-Out Easily Corrected

According to Mr. Hoover, axle construction which slants the wheels closer together at the bottom is commonly termed camber and the tilt of the axle is known as caster. Both of these factors play an important part in front-wheel alignment, and if they are of an amount unsuited to the conditions they cause excessive wear on the side of the tire tread. The speaker said also that a feather edge on one side of the tire tread is an indication of wear caused by an unsuitable amount of toe-in. Tire wear due to an unsuitable length of turning radius is not easy to determine because the tread in such case shows excessive but even wear across its face. Improper amounts of toe-in and toe-out can be corrected easily, if excessive tire wear indicates the necessity, by adjustments of the tie-rods and by properly aligning the axle to make camber and caster greater or less.

Mr. Hoover said that many of the fundamental causes of shimmy can be attributed to tires. Causes originating from the tires are the deflection rate of the tire, balance, air pressure, radial run-out, side run-out, non-uniformity of tread thickness, and internal friction in the tire.

Basis of Successful Front-Wheel Alignment

It was brought out by Mr. Bushey that the foundation of successful front-wheel alignment lies in adjusting the parts underneath the frame of the vehicle so as to distribute the weight of the vehicle in a manner that will prevent detrimental friction of the tires on the road. To obtain this result, his company has adopted a system that includes a thorough inspection of all parts underneath the frame and the recording or charting of each measurement before diagnosis of the unsatisfactory conditions is made. He said that the mere adjustment of camber, caster and toe-in is not the solution, because it is necessary also to take into consideration load, speed, wheelbase, type of the front and rear-end assemblies, size of the wheel, size and type of tire, and similar items. If any one of the parts he enumerated is worn, out of adjustment, out of balance, or out of alignment, it will cause premature tire wear either directly or indirectly and will also be a contributory cause to such problems as shimmy, romping, wandering and flighty steering.

After defining the terms used in connection with problems of front-wheel alignment and analyzing their effects,

Messrs. Hale and Stewart stated in their paper that all these considerations apply equally well to all classes of motor-vehicle, whether they run on balloon tires, heavy-duty high-pressure pneumatic-tires, or solid-rubber tires.

Discussing the subject of front-wheel shimmy, these authors state that two distinct types of shimmy exist. The first is a slow-speed shimmy or wabble, which is merely a turning of the front wheels from one side to the other side at any vehicle speed up to perhaps 30 m.p.h., and this type is relatively easy to rectify. The second type, called high-speed shimmy, is a violent lateral oscillation of the wheels and is accompanied by a violent tramping of the axle in a vertical plane around a longitudinal axis. It is a type of shimmy that has been noted at speeds of from 30 to 70 m.p.h.

Slow-speed shimmy is caused by worn or bent parts, such as drag-link and tie-rod connections, king-pin bearings, wheels, tie-rods and axles. The authors state that high-speed shimmy results, not from one particular glaring error in vehicle or tire construction, but from myriad forces, most of them present in the modern car. Sometimes these forces work together and have a pyramiding effect, and sometimes they oppose and damp-out each other.

The major causes of high-speed shimmy are: gyroscopic action, periodicities of vibrations, design and mechanical conditions of the front axle and the steering linkage, and the effect of the tires. These causes are considered in detail in the paper.

In conclusion, it was stated that the following precautions should be kept in mind as being helpful in increasing the life of tires and decreasing shimmy:

(1) Check the camber, caster, and toe-in frequently and keep them within proper limits for the conditions of service
(2) Replace worn or bent parts in the front end of the car promptly
(3) Line up the drag-link so that the connections of the drag-link to the pitman arm, and from the drag-link to the steering-arm and the front spring-bolt, form as nearly as possible a straight line
(4) Keep the balance of the wheel and tire assembly within reasonable limits, say within 50 oz-in.
(5) Keep the tires inflated to the recommended pressure
(6) Retard the front-spring deflection and change the period of vibration in some way. To do this (*a*) keep the shock-absorbers tight, (*b*) do not oil the springs or (*c*) add an extra leaf

In the general discussion which followed, numerous questions were asked and answered in regard to the details of procedure for the correction of defects in proper alignment. The advisability of heating parts, such as axles, to straighten them was seriously doubted, the reason being that too great a liability exists that the parts so treated will not again return to the original strength that was due to the heat-treatment they received in the process of manufacture.

Resetting of the front springs was mentioned as a means of minimizing shimmy. Under-inflation of tires was also named as a cause of shimmy, an instance being cited in which this trouble was cured by inflating the tires to a proper pressure. In this connection it was said that under-inflation has the effect of increasing the amount of caster, which is one reason that under-inflation causes shimmy. It was stated that wheel wabble has a decidedly detrimental effect in that it causes excessive tire wear.

DAYTON SECTION HEARS GRANT

At a joint meeting of the Dayton Section with the Dayton Engineering Club on Dec. 5, the speaker of the evening was R. H. Grant, of the Chevrolet Motor Co., who gave one of his characteristic interesting extemporaneous talks on the subject, What Sells Automobiles. This meeting was to be followed by another later in December, but the speaker and the date had not been determined at the time of last advice from Secretary F. W. Heckert of the Section.

At the Section's meeting on Nov. 29 Roger J. Emmert, of the Delco-Remy Corporation was chosen as member and V. G. Apple, of the Vincent G. Apple Laboratories, was elected alternate for the Nominating Committee to attend the Annual Meeting. At the same meeting a vice-chairman for the Section was elected to succeed F. G. Shoemaker, who had moved to Syracuse, where he is now connected with the H. H. Franklin Mfg. Co.

Brakes Considered from Various Angles

Big Detroit Section Meeting Hears Views of Local Police Officials, Brake Manufacturer, Automobile Engineers and an Operator

Another record-breaking gathering of members of the Detroit Section was held in the Crystal Room of the Book-Cadillac Hotel on Dec. 5, when the problem of brakes was discussed by men who view it from four different angles. Walter T. Fishleigh, chairman of the Section, presided.

Lieut. John W. Bates and Sergeant Brown, of the Detroit police force, attended the meeting as representatives of Inspector Schink, director of traffic. Lieutenant Bates made a brief appeal for safety in the streets and said that his only objection to four-wheel brakes is that they encourage irresponsible drivers to excessive speed between street intersections, thus frightening pedestrians who are using the crosswalks.

Sergeant Brown presented a brief paper on What Automobile Brakes Should Accomplish. After complimenting the automotive engineers on making a vehicle that would make Nero or Louis XVI envious, he said that he would not tell the engineers how to improve their handiwork, but would ask their aid in solving the problem of street traffic accidents. Automobiles destroyed eight times as much property last year in Detroit as all the criminals took from the citizens, twice as many people were killed by drivers as by gunmen, and in addition 12,000 Detroiters were sent to the hospitals by drivers, according to Sergeant Brown. During the World War more citizens of Detroit were killed on the streets of the city than were killed by all the armies on the battle fields of France.

Safety engineers attributed 90 per cent of the responsibility for accidents to the human element and 10 per cent to mechanical failures. Sergeant Brown is convinced that this estimate of the mechanical factor is too small, although reports of traffic accidents secured by the Detroit Police Department are filled out either by drivers who have a traffic ordinance violation to conceal, or by officers who overlook facts in their excitement and hurry. He believes that better equipment, and especially better brakes, would reduce traffic accidents at least 25 per cent.

In a road experience of the officer during a cross-country drive several years ago, immediately after relining the brakes, his foot brakes lasted only one-third of the way down a mountain, the hand brakes for another third of the way, and the last and steepest third of the descent was a desperate adventure. Real improvement in brakes has been made since then, but the driving speed has been increased

in proportion, so the brakes are no safer under present conditions.

Annual brake-test campaigns have shown that, of about 200,000 automobiles tested, one-quarter fail to pass the low required standard of ability to stop within 37 ft. from a speed of 20 m.p.h. Many of the cars tested were new and they were voluntarily submitted for test. As it is hardly to be supposed that a driver who knew his brakes were defective would submit voluntarily to such a test, defective brakes seem to be the rule, said Sergeant Brown.

Improvements in Mechanical Brakes

Brake manufacturers were represented by R. M. Heinrichs, who presented a paper written by himself in collaboration with John R. Cautley, both of them connected with the Bendix Brake Co. The best mechanical systems, according to the authors, are so arranged that at least two of the brakes are effective even in case a part of the mechanism is broken. Many improvements in detail are being made to assure dependability and the maximum braking effect with a moderate pedal pressure and travel. Servo action is secured by making the drag of one brake-shoe apply pressure to a second shoe, and controllability requires that this transferred pressure shall not be great enough to cause locking of the brake or any braking action that is not proportional to the pedal pressure.

Simplicity of the operating mechanism is desirable, and the growing tendency to connect the hand-brake lever with the four-wheel brakes rather than using an entirely separate braking system was commended. Protection of the braking surfaces against loss of effectiveness due to water and other foreign substances, secured by the enclosed internal-brake design, was stressed.

Two papers presented the viewpoint of the automobile manufacturer. The first was by W. R. Strickland, assistant chief engineer of the Cadillac Motor Car Co. and nominee for First Vice-President of the Society. He was obliged to abridge his paper on Ideal Four-Wheel Brakes because of time limitation.

Among the shortcomings of some present brakes the following were mentioned: variation in coefficient of friction, expansion and distortion of drums or shoes from heat, and effect of water and oil.

Mr. Strickland approved the tendency to use the engine for braking on long hills, as directed by signs erected by the authorities of many States. If the proper gear is engaged, the engine can do the braking without wearing out and it would make an ideal braking system were it infinitely variable. The brake-lining manufacturers make for their product claims that encourage too great expectations on the part of the user, according to the speaker. A campaign is needed to educate the drivers to have their brakes inspected frequently and to keep them in good condition.

While present brakes are not ideal, many forms of brake are now in use that will protect the owner at all proper speeds and more, if they are suitably serviced. According to Mr. Strickland, brake manufacturers should do less bragging and more cautioning of drivers, directing how often the brakes should be inspected and relined on a mileage basis, just as is done with some other adjustments and with lubrication.

Advantages of Hydraulic Brakes

Hydraulic brakes were discussed specifically by S. C. Pearson, assistant engineer of the Reo Motor Car Co., who stressed particularly the equal application secured at all four wheels; ease of servicing and freedom from need of frequent adjustment; and their convenience and economy in assembling, due to the possibility of making them in the form of convenient subassemblies that require little adjustments on the car-assembly line.

Convenience in servicing is secured by exchanging shoes with worn linings for shoes with new linings which can be inserted without making delicate adjustments, since the adjustment affects the clearance but not the equalizing. Little allowance is needed for leakage, as the master cylinder operates inside the liquid supply tank and any leakage will be replaced at each application of the brakes.

The operator's point of view was represented by Paul D. Harvey, who is in charge of the operation of the Garage Service Co., which has a fleet of 260 vehicles that make a total mileage of more than 4,000,000 miles per year in the Hearst newspaper service in Chicago.

Brakes were said by him to have been one of the greatest single sources of trouble and expense in the operation of these vehicles, which include saelsmen's coupes and delivery vehicles ranging in capacity from ½ to 2½ tons, which make a great number of stops necessitated by the schedule and the traffic. Cars on delivery routes average 350 stops per day, while trucks doing relay duty average 150 stops per day.

About 2 years ago the company decided to build twelve 1-ton vehicles designed by Mr. Harvey especially for this service and equipped with four-wheel brakes made by a well-known axle manufacturer. The experience with these brakes was so satisfactory that subsequently, when some 2-ton trucks were needed, they were provided with the same brake equipment, which is said to have eliminated brake trouble and side skidding and to have increased the brake-lining mileage greatly.

Make Your Reservations Early

The unexpectedly large attendance at the meeting made a slight delay in the dinner which preceded it, and at which entertainment was provided by a girls' orchestra and by several singing and dancing artistes. After dinner and before the technical session, a short business session was held at which Edward V. Rippingille was elected Detroit Section member of the Nominating Committee of the Society and John H. Hunt, L. M. Woolson, George L. McCain and F. E. Watts were elected to serve with Section Chairman Fishleigh as a nominating committee for officers of the Section.

Plans of the Membership Committee of 15 members, which met before the dinner, were outlined by Bert J. Lemon, its chairman, who said the plan is to select key men in the various industries and plants in the Detroit territory who will distribute letters and literature, send in names of prospects, and follow this up with personal work. It is intended to seek as members only those who have a real interest in the work of the Society.

Charles B. Whittlesey, Jr., assistant to the general manager of the Society, assured the members that the Society will support the Section in its campaign. Mr. Whittlesey spent some time in Detroit assisting in the work of the Membership Committee.

BIG STUDENT-BRANCH MEETING

One Thousand M. I. T. Students and Guests See Motion Pictures of New Car Assembly

Five reels of motion-picture films officially showing the construction of the new Model-A Ford car were exhibited before an intensely interested audience of nearly 1000 at the meeting of the Student Branch of the Massachusetts Institute of Technology which was held Dec. 9. All available space in the large auditorium was occupied and more than 200 were turned away. Since so many were unable to gain admission, a return showing of the film has been requested. The film was secured through the courtesy of Prof. Charles F. Park and of W. A. Francis, general manager for New England of the Ford Motor Co.

The pictures show close-up views of details of construction and of assembling, inspecting and testing. They are illustrative also of the numerous new features and the methods of applying new and more exacting standards of measurement.

A brief address was delivered by R. C. Purdy, of the Ford Motor Co., who described the principal changes in the car and, after the showing of the pictures, gave further detailed explanations to interested students and guests. Mr. Purdy was introduced by Arthur A. Nichols, '28, chairman of the Student Branch.

Some of the features of the pictures that compelled the greatest interest were the methods of balancing the crankshaft and those relating to the matching and fitting of the parts. Particularly noticeable was the use made of multiple-unit machine-tools and of machine-tools used to perform operations that ordinarily are done by hand.

Some amusement was occasioned by the comments of the student spectators during the exhibition and by the blowing of an automobile horn when the completed car was shown as it was driven from the assembly line. After the meeting, members of the Society met the students informally and gave information regarding membership requirements and advantages. A considerable number of applications for membership were filed.

Guests for the occasion included members of several of the large automotive firms in Boston, members of the Cambridge Rotary Club, prominent engineers, and guests of members of the faculty of the Institute.

ROBERT McALLISTER LLOYD

IN the passing away of Robert McAllister Lloyd at his home in New York City on Dec. 14, the automotive industry loses another of its pioneers, as Mr. Lloyd was active in the development of the storage battery and the electric truck in the closing years of the last century and early years of the Twentieth Century.

One of his important early works in the electrical field was the organization of the Planté Co., which was later purchased by the Electric Storage Battery Co., by which Mr. Lloyd was retained as consulting engineer. In 1901 he organized the Vehicle Equipment Co., which was subsequently reorganized as the General Vehicle Co. and operated successfully until early in 1917.

Mr. Lloyd was elected to membership in the Society in September, 1910, at which time he was vice-president and engineer of the General Vehicle Co., and was an active and interested member of the organization. A paper by him on Cooperation Between the Electric Vehicle Manufacturer and the Central Station was published in TRANSACTIONS for 1911, and an address delivered by Mr. Lloyd at the Annual Dinner of the Society was published in Part I of TRANSACTIONS for 1912. He was also much interested in and took an active part in the affairs of the Metropolitan Section of the Society in the earlier years of its activities.

Mr. Lloyd was born in Elizabeth, N. J., in 1864, received his preparatory education at the Germantown Academy, Philadelphia, and his technical education at Lehigh University. From 1899 to 1900 he was president of the Electric Vehicle Co., and from 1901 to 1906 was president of the Vehicle Equipment Co. In addition to the connections mentioned, Mr. Lloyd was president of the firm of Mantle & Co., engineers, and a short time ago founded the Sealed Containers Corporation.

Besides holding membership in the Society of Automotive Engineers and several other engineering societies in this Country, Mr. Lloyd was a member of the Institution of Electrical Engineers of Great Britain and was affiliated with the Century, Union, Piping Rock, and other clubs.

He is survived by his wife, his son, Robert McAllister Lloyd, Jr., and two daughters, the elder of whom is married, and the younger of whom is a sophomore student of Vassar College. Funeral services were held in New York City, and interment was at Mifflintown, Pa.

THEODORE POMEROY

THEODORE POMEROY, who was president and treasurer of the KP Products Co. and vice-president of the investment banking firm of Case, Pomeroy & Co. in New York City, died suddenly on Dec. 3, in Tucson, Ariz., where he had gone several weeks previously, suffering from heart trouble. Funeral services were held on Dec. 7 in Chicago, where, prior to 1916, Mr. Pomeroy was associated for several years with the investment house of King, Farnum & Co.

Mr. Pomeroy had been an associate member of the Society since October, 1925. Born in January, 1887, at Pittsfield, Mass., he attended the Hill School in Pottstown, Pa., and was graduated in 1909 by Yale University with the degree of bachelor of arts. In 1918 he was president and treasurer of the Automotive Supply Corporation, for which he was engaged in the development of automobile vacuum pumps and carbureters. In the following year he became president and treasurer of the KP Products Co., for which he was engaged in the development of vacuum carbureters and vacuum gas-engine governors, and was active in financing the development and marketing of these devices. He was a member, at the time of his death, of the Metropolitan, Yale and Bankers Clubs in New York City.

He is survived by his mother, Mrs. Christina King Pomeroy, in Chicago; his wife, Mrs. Louise Schulze Pomeroy; and his son, Theodore Pomeroy, Jr.

Applicants for Membership

The applications for membership received between Nov. 15 and Dec. 15, 1927, are listed below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ALEXANDER, DON M., first vice-president in charge of engineering and construction, Alexander Industries, Inc., *Denver.*

ALLEN, HORACE R., checking and tool design, Marmon Motor Car Co., *Indianapolis.*

BAILEY, ALFRED, director of overseas sales, Ferodo, Ltd., *Chapel-en-le-Frith, England.*

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BION, JOHN W., assistant purchasing agent, New York Edison Co., *New York City.*

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CHAPIN, LAWRENCE W., assistant to service manager, Twin Coach Corporation, *Kent, Ohio.*

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JOHNSON, J. P., president, J. P. Johnson Engineering Co., *Cleveland.*

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LOHMANN, OTTO, technical director of manufacturing department, Mauser-Werke, Aktiengesellschaft, *Oberndorf am Neckar, Germany.*

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MCSHANE, CARROLL A., manager of service department, Jordan Philadelphia Co., *Philadelphia.*

MORRELL, G. ARTHUR, district manager, Formica Insulation Co., *Cincinnati.*

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SEABURY, RALPH L., owner and manager, Ralph L. Seabury, *Toledo, Ohio.*

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TITUS, RALPH H., president, Ralph H. Titus, Inc., *New Rochelle, N. Y.*

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WESTCOTT, B. W., research engineer, Zenith-Detroit Corporation, *Detroit.*

WIMMER, GLEN E., engineer and draftsman, General Electric Co., *Fort Wayne, Ind.*

WOLFRAM, JOHN F., experimental engineer, Chandler-Cleveland Motors Corporation, *Cleveland.*

YOSHINO, JINSHIRO, naval inspection, Japanese Naval Inspector's Office, *New York City.*

YUAN, TSUNG-TOH, student, Massachusetts Institute of Technology, *Cambridge, Mass.*

Applicants Qualified

The following applicants have qualified for admission to the Society between Nov. 10 and Dec. 10, 1927. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member.

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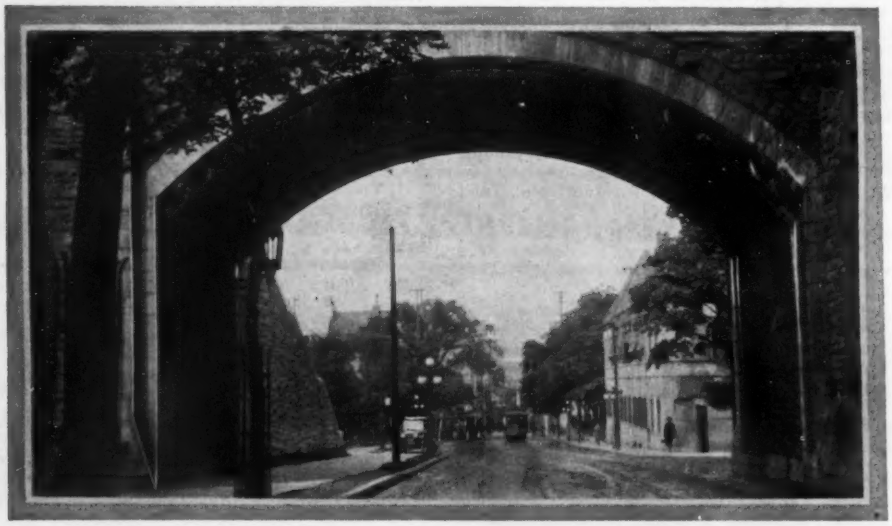
Representatives: Townsend, R. A., metallurgist
Van Dorn, J. T., assistant works manager

WEBSTER, FRANK B. (A) sales manager, Service Parts Co., 2016 Grand Avenue, *Los Angeles*.

WEBSTER, T. ELLWOOD (A) vice-president, Celoron Co., *Bridgeport, Pa.*

WOOLLEY, H. S. D. (A) superintendent, Breay Nash Motors, Ltd., *Toronto, Ont., Canada;* (mail) 146 Courcelette Road.



ENTERING QUEBEC THROUGH THE ST. LOUIS GATE